T.C.
MİLLÎ EĞİTİM BAKANLIĞI

MOTORLU ARAÇLAR TEKNOLOJİSİ

MOTOR TEKNİK YABANCI DİLİ (İNGİLİZCE)

222YDK129

Ankara, 2011

- Bu modül, mesleki ve teknik eğitim okul/kurumlarında uygulanan Çerçeve Öğretim Programlarında yer alan yeterlikleri kazandırmaya yönelik olarak öğrencilere rehberlik etmek amacıyla hazırlanmış bireysel öğrenme materyalidir.
- Millî Eğitim Bakanlığınca ücretsiz olarak verilmiştir.
- PARA İLE SATILMAZ.

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AÇIKLAMALAR

KOD	**222YDK129**
ALAN	**Motorlu Araçlar Teknolojisi**
DAL / MESLEK	**Tüm Dallar**
MODÜLÜN ADI	**Motor Teknik Yabancı Dili (İngilizce)**
MODÜLÜN TANIMI	Otomotiv sektöründe kullanılan elektromekanikerliği teknolojisi ile ilgili temel tanım ve terimlerin İngilizce karşılıklarını ve kullanım şekillerini içeren öğretim materyalidir.
SÜRE	40 / 32
ÖN KOŞUL	Bu modülün ön koşulu yoktur.
YETERLİK	Yabancı dilde mesleki konuları dinlemek, konuşmak, okumak ve yazmak
MODÜLÜN AMACI	**Genel Amaç** Otomotiv elektromekanik teknolojisi ile ilgili Teknik İngilizceyi, okuma, anlama, yazma ve konuşma düzeyinde öğrenebileceksiniz. **Amaçlar** **1.** Otomotiv motor teknolojisi ile ilgili Teknik İngilizce' yi kullanabileceksiniz. **2.** Otomotiv güç aktarma organları teknolojisi ile ilgili Teknik İngilizce' yi kullanabileceksiniz. **3.** Otomotiv hareket kontrol sistemleri teknolojisi ile ilgili Teknik İngilizce' yi kullanabileceksiniz. **4.** Otomotiv elektrik-elektronik teknolojisi ile ilgili Teknik İngilizce' yi kullanabileceksiniz.
EĞİTİM ÖĞRETİM ORTAMLARI VE DONANIMLARI	**Ortam:** Sınıf, elektro-mekanik atölyeleri, kütüphane **Donanım:** TV, VCD, Video, Internet
ÖLÇME VE DEĞERLENDİRME	Modül içinde yer alan her öğrenme faaliyetinden sonra verilen ölçme araçları ile kendinizi değerlendireceksiniz. Öğretmen modül sonunda ölçme aracı (çoktan seçmeli test, doğru-yanlış testi, boşluk doldurma vb.) kullanarak modül uygulamaları ile kazandığınız bilgi ve becerileri ölçerek sizi değerlendirecektir.

INTRODUCTION

Dear student;

Nowadays, knowing of foreign language is a fact that cannot be ignored. And everyone knows this fact. It has become an important part of people's daily lives. If people know a foreign language, they can find a job easily. In addition, It is possible to achieve better wages.

We live in the time period described as the information age. The information age has accelerated the development of technology. In addition, information life and of time the validity is short increasingly. Therefore, the information obtained must be kept up to date. At this point, you need to know a foreign language in order to be a step ahead.

Today, English has been adopted by the whole world and was accepted as a world language. All issued information are translated into English and are published.

The automotive sector is developing very fast. The highest using of technological developments has become an industry branch. Therefore, If people work in this area, they need to know to Technical English.

This module is about electro-mechanics technology in the automotive sector. This module includes English equivalents and usage patterns of the basic definition and terms. With this module you will follow the developments in the field of automotive and will have the knowledge of technical English.

LEARNING ACTIVITY-1

AIM

You will use the technical English about automotive engine technology.

SEARCH

- Research the basic definitions and terms with the relevant automotive field using automotive services in your surroundings and at your school workshops and what happening with the equivalents of technical English. Bring into a report the results of making research. Make a presentation to your teacher and your friends in your classroom.

1. AUTOMOTIVE ENGINE TECHNOLOGY

1.1. Main Definitions and Terms of Automotive Technology

1.1.1. Dead Centre

In the cylinder of the piston, dead center is the point where piston stops long time because it changes the direction of its motion.

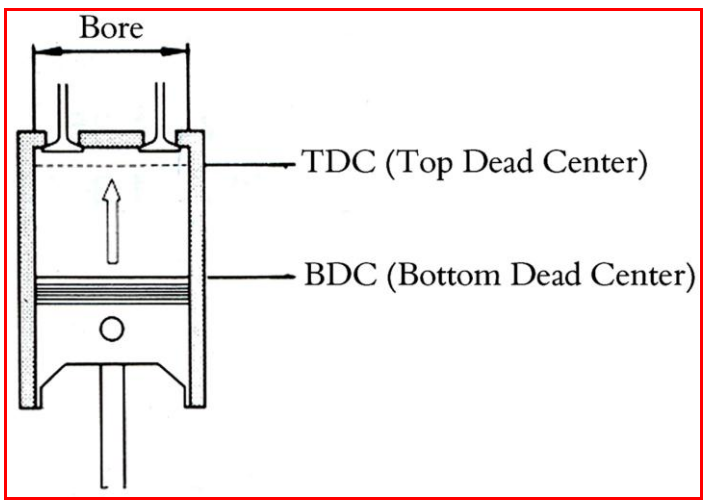

Figure 1.1: Dead centers of cylinder

1.1.1.1. Top Dead Centre (T.D.C.)

In the cylinder, the crown of the piston reaches at the top. In the case of an engine the term “top dead center (T.D.C.)” refers to the position of the piston at the top of its stroke.

1.1.1.2. Bottom Dead Centre (B.D.C.)

In the cylinder, the crown of the piston reaches the bottom. The term “bottom dead centre (B.D.C)” refers to where the piston is at its lowest position.

1.1.2. Stroke and Stroke Volume (SV) (Swept Volume)

Stroke is the distance in the space where the piston moves in the cylinder, that is, the distance between top dead center and bottom dead center.

Stroke is a movement that the piston makes (moves) between dead centers in the cylinder. As theoretical, a stroke is formed for crankshaft to turn off 180°.

Bore is the diameter of the cylinder.

Stroke volume is the volume between T.D.C. and B.D.C. Total stroke volume products stroke volume and cylinder numbers of an engine

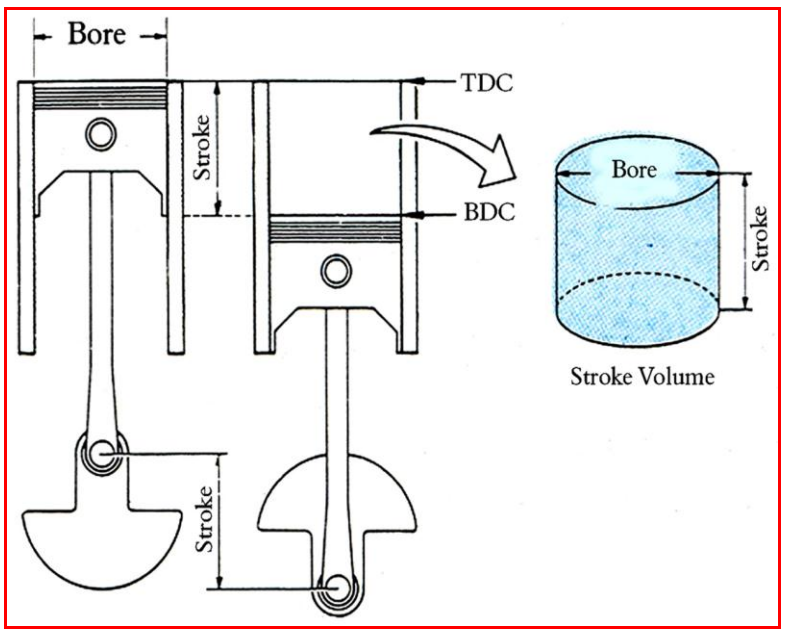

Figure 1.2: Stroke and stroke volume

1.1.3. Combustion Chamber Volume (CCV) (Clearance Volume)

Combustion chamber volume is the volume between the crown of the piston and cylinder head while the piston is at T.D.C.

1.1.4. Cylinder Volume

Cylinder volume is the total of stroke volume and combustion chamber volume. Total cylinder volume is the product of cylinder volume and cylinder numbers of an engine.

1.1.5. Compression Ration

$$CompressionRation = \frac{CombustionChamberVolume + StrokeVolume}{StrokeVolume}$$

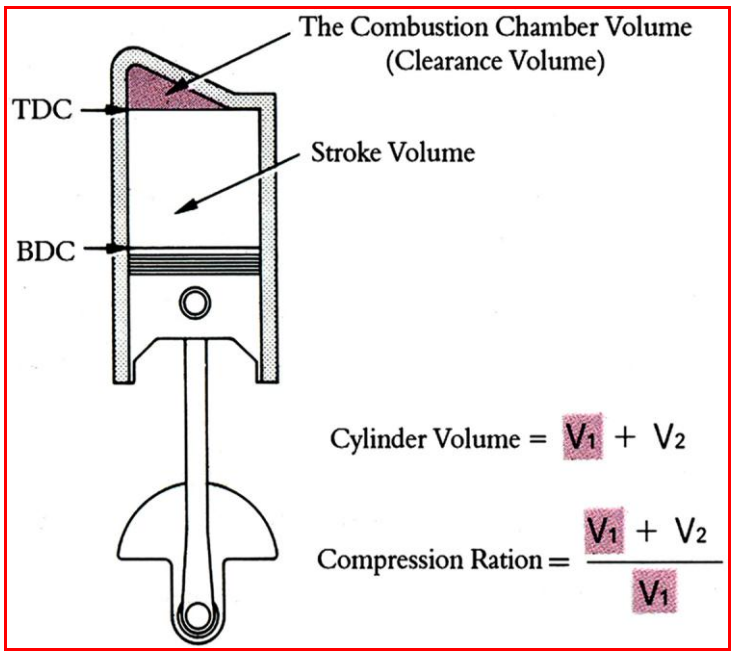

Figure 1.3: The combustion chamber volume and compression ratio

1.1.6. The End of the Compression Stroke

The end of the compression is the position that two valves are covered (closed) and that the piston is at T.D.C. during the end of the compression stroke and the start (beginning) of power stroke.

1.1.7. Overlap of the valves

Overlap of the valves is the position that two valves are uncovered and that the piston is at T.D.C. during the end of the intake stroke and the start of exhaust stroke.

1.2. Classification of the Engines

1.2.1. According to Cylinder Design (According to Arrangements of Engine Cylinder)

Vehicle engines are usually classified according to the number and actual arrangement of the cylinders in the engine block. In most of the cars and light commercial vehicles commonly used cylinder arrangements are the in-line and V-formation type although other designs may be employed.

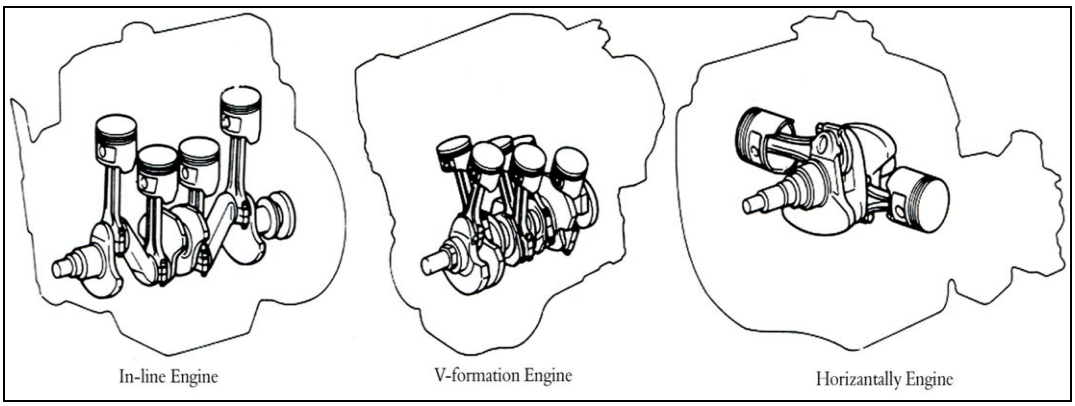

Figure 1.4: According to arrangements of engine cylinder

- **In-line Engines**

  The most popular arrangement to use in the small and medium sizes of vehicles is probably the four-cylinder in-line engine. In-line engines may also have two, six, or even eight cylinders mounted in straight line, one after the other. Usually the cylinders are formed in a vertical bank above the crankshaft as indicated in Fig 1.4. On some engines, the cylinders are inclined from the vertical so overall engine height can be reduced and space conserved in the engine compartment. The cylinders are usually numbered from front to rear although there are some manufacturers who number their engines from the rear to the front.

- **V-Formation Engine**

  In "V" engines the cylinders are mounted above the crankshaft to form the letter "V" when viewed from either end (Fig.1.4). The cylinders are usually cast integrally with the crankcase in two rows or banks which are set at either a right angle *or* an acute angle to each other. Although engines with sixteen cylinders have been produced in the past, most V-engines are now produced in four, six, eight and occasionally twelve cylinder arrangements. The V-type engine has the advantage of being much shorter than the in-line arrangement. It does not occupy as much space when installed in the vehicle. If the overall length of the engine can be reduced, the crankshaft can be made more rigid with fewer

tendencies toward internal or torsional vibration. In most arrangements the cylinders are numbered starting from the front of the left-hand bank, and then continuing from the front of the right-hand bank.

- **Horizontally Opposed Engines**

  The engine has two banks of cylinders mounted directly opposite to each other on the crankcase as indicated Fig 1.4. These are sometimes referred to as "flat" engines and are usually produced in two, four, and six cylinder arrangements. The pistons move inwardly and outwardly together providing excellent balance and regular firing intervals. Horizontally opposed engines are admirably suited to air cooling and have proved to be very successful in operation. The most notable design was the four-cylinder, horizontally opposed, air-cooled Volkswagen engine. The cylinders are numbered in the same manner as in the case of a V-engine.

1.2.2. According to Cylinder Numbers

According to cylinder numbers, vehicle engines are classified single-cylinder engines and multi-cylinder engines. Multi-cylinder engines are usually produced two, three, four, six, eight, twelve and sixteen cylinders. In most of the vehicles usually used engines have four, six and eight cylinders.

- **In-line Twin Cylinder Engine**

  There are two possible crankshaft designs which can be used in this arrangement of cylinders. In one design the crankpins are aligned with each other, with the pistons moving up and down together. When the engine is operating on the four-stroke cycle, there is an equal firing interval of 360°, but the overall engine balance is poor as the reciprocating weights cannot be balanced. There is a smoother crankshaft torque than in a single cylinder engine and this type has been extensively used in the design of motor-cycle engines.

- **In-line Four-Cylinder Engines**

  This type of engine is the most popular arrangement for small and medium sized private car light commercial vehicles.In-line four-cylinder engines are most often found in lightweight economy and sports cars. They are short enough to be placed sideways (called transverse mounting) in some front-wheel-drive models. Most tours vibrate noticeably especially at low engine speeds.

- **In-line Five-Cylinder Engines**

  In-line five-cylinder auto engines were unheard until Mercedes-Benz introduced a five-cylinder diesel passenger car engine in 1974. The main advantage of a

live is that it produces more power than a four but takes up less space than an in-line six. A V-6, however is even more compact and it can be mounted transversely in a front-wheel-drive car while a live cannot

- **In-line Six-Cylinder Engine**

  In-line six-cylinder engines are longer and heavier than fours and fives but are generally smoother and more powerful. Sixes are the traditional "small" engine option in large North American sedans and station wagons. There can be a lot of working room around an in-line six in the engine compartment of a wide modern car. Most sixes stand upright like the one in the illustration but Chrysler Corporation slants its six at a 30° angle which lowers its center of gravity somewhat.

- **Flat-Four Engine**

  Flat-four engines have two parts of cylinders arranged horizontally. Air cooled flat-4s were made popular throughout the world in Volkswagens. Water-cooled fIat-4s are now manufactured by Alfa Romeo, Lancia and Subaru. Chevrolet once made an air-cooled flat-6 for the controversial Corvair and Ferrari currently makes a powerful water-cooled flat-12 for the Berlinella Boxer model.

1.2.3. According to the Valve System of Engine

- L Type
- I Type
- T Type
- F Type

1.2.4. According to Cooling System of Engine

- The cooling system with air
- The cooling system with water

1.2.5. According to Fuel

- Gasoline engine
- Diesel Engine
- LPG Engine
- HydrogenEngin1.3 Main Part of the Automotive Engines

1.3. Main Parts of the Automotive Engines

1.3.1. Stationary Parts of the Engine

- **Cylinder (Engine) Block**

The cylinder block is the main shell of the engine. Most blocks are made of cast iron but a few are aluminum which is lighter and conducts heat better. Because aluminum is too soft to withstand the constant rubbing of the piston, most aluminum engines have cast-iron sleeves (called liners) inserted in the cylinders. The block can have many cracks if water freezes and expands in these passages. Sometimes this expansion will dislodge the core plugs-discs that seal holes required during the casting process and for this reason the core plugs are sometimes referred to as freeze-out plugs. However the core plugs are not reliable safety valves and it is important to maintain at least a 50 percent concentration of antifreeze in the engine's cooling system.

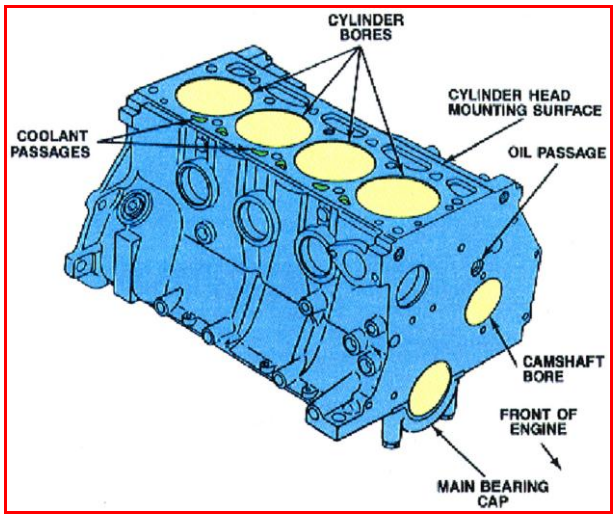

Figure 1.5: In-line four-cylinder engine (cylinder) block

➢ **Cylinder Head (Cover)**

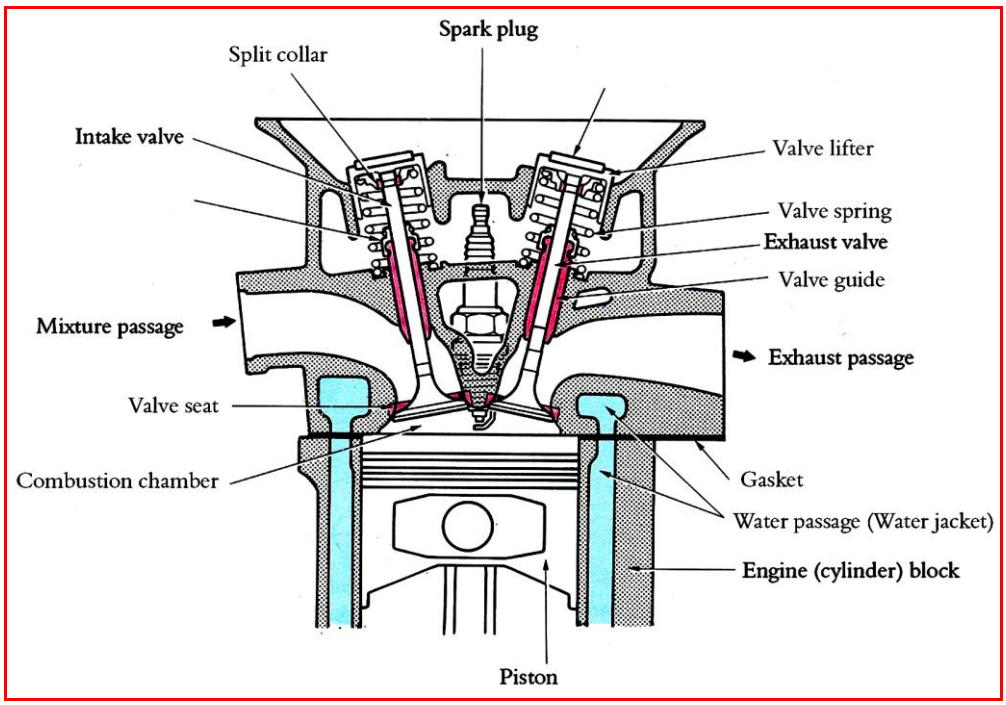

Figure 1.6: Description of each part of cylinder head (cover)

The cylinder head corresponds to the head of an engine consisting of water jackets for cooling combustion chambers and their surroundings intake and exhaust valve holes gas passages past those valves intake and exhaust manifolds spark plug holes and lubricating oil passages.

The cylinder head is usually cast from iron or from aluminum alloy. Most modern engines use an aluminum alloy head which combines the advantages of lightness and high heat conductivity.

Head gasket provides a seal between the cylinder block and head to prevent the escape of gases and fluids. It is pierced by many holes, the large ones for the cylinders and the smaller ones for the pushrods, studs, and oil and water passages. The gasket is often made of a compressible material such as asbestos with a copper or steel cover.

➢ **Liners**

- **Wet Liner**
  The engine block contains holes in which the liners are inserted. The liners are "wet" when their external surface is in direct contact with cooling water.

On the top part of the block, water tightness is obtained through direct metal to metal bearing. At the bottom through tight joints inserted in grooves cut in the lower part of the liner or of the block, or by means of a bearing and brass joint.

- **Dry Liners**
  This is a thin sleeve made of cast iron or of stee1 which is forced into a hole bored in the block. Thus a liner is not in direct contact with the cooling liquid.

➢ **Manifolds**

- **Intake Manifold**
  Formal name is “inlet manifold” but it is more generally called “intake manifold”. It is used with a multi-cylinder engine for distributing the air-fuel mixture fed from the carburetor to all the cylinders. Its primary role is to uniformly deliver the mixture to all cylinders but it should also play another very difficult role that is to uniformly distribute the gasoline which flows along the wall of the manifold in liquid state, as well as the atomized gasoline. Furthermore the intake manifold also assists the atomization of gasoline because this does not occur only in the carburetor.

- **Exhaust Manifol**
  An exhaust manifold plays the role of gathering exhaust gases from multiple cylinders into single or dual flow. It is designed for the functions of avoiding interference to the exhaust gas from other cylinders and of allowing exhaust at high efficiency to contribute to the increase of power output by reducing the volume of gases remaining in the cylinders at the same time.

The material of an exhaust manifold for a mass-produced engine is generally cast iron.

- **Oil Pan**

  The oil pan acts as a reservoir for oil, and it also serves as a dust shield for the bottom of the engine. It is attached to the bottom of the block with cap screws. The pan is generally made of thin steel stamped to shape.

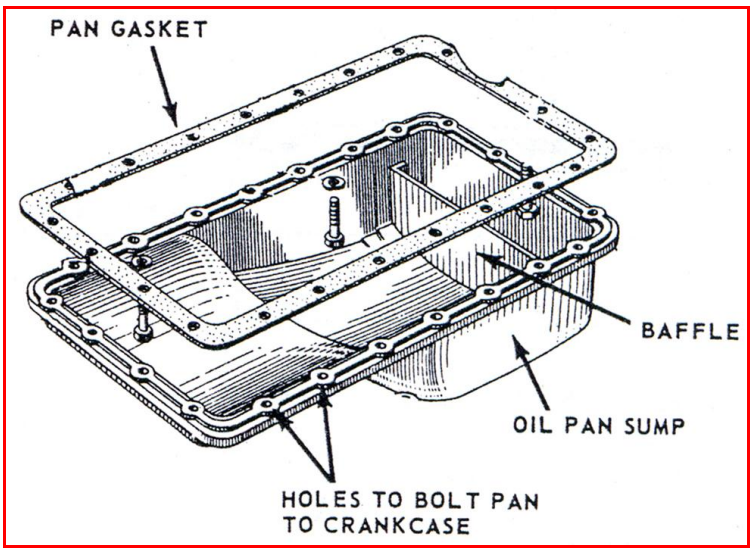

Figure 1.7: Oil pan

1.3.2. The Moving Parts of the Engine

- **Piston**

As the piston is pushed down by the combustion pressure of high-temperature burned gases, the crankshaft is rotated through the connecting rod. Thus, the piston must meet the following requirements.

1. The piston must be strong enough to withstand high temperatures.
2. To prevent seizure during reciprocating motion the piston must have a practical shape with an adequate cylinder clearance. It must also be able to keep the cylinder wall lubricated.
3. Small amount of frictional resistance.
4. Both the piston and the piston rings must possess good wear-resisting properties.
5. Lightness.

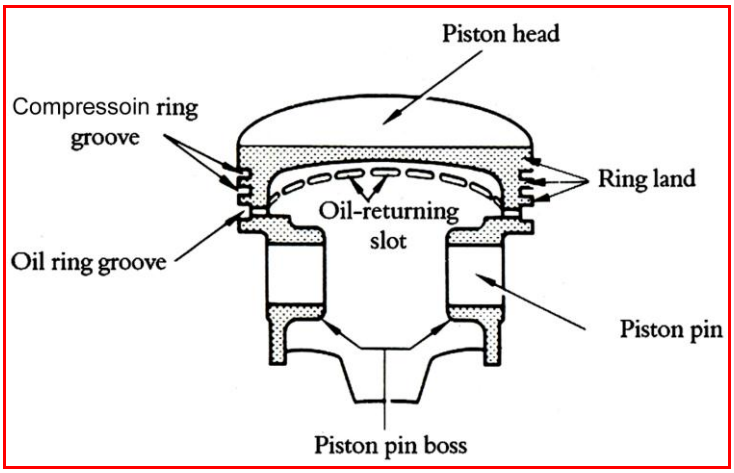

Figure 1.8: Description of each part of piston

Pistons are usually made of aluminum. Often aluminum pistons are tin-plated to allow a good breaking-in job when the engine is started. Aluminum pistons can be forged but are more commonly cast. The aluminum piston is light and for most purposes, this gives it an advantage over the cast iron type. A piston must change its direction of travel at the end of every stroke. At speeds sometimes in excess of four thousand revolutions per minute (rpm), it is obvious that the lighter the piston is the more efficient it will be. Cast iron is a good material for pistons used in a slow speed engine. It has excellent wear characteristics and will perform admirably in an engine suited to its needs. Pistons which are designed to operate in silicon aluminum cylinders are iron-plated aluminum.

Pistons must be carefully fitted into engine cylinders to prevent them from tipping from side to side. They must hold the burning fuel charges above the pistons and be tight enough to form a vacuum, compress and exhaust burned gases. A piston will expand when it gets hot, so enough clearance must be left to allow for this. Aluminum pistons expand more than cast iron (Figure 1.9).

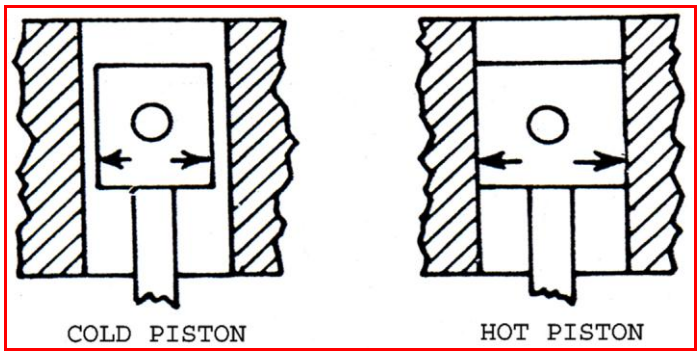

Figure 1.9: Exaggerated view shows effect of heat on piston expansion.

The problem of fitting the aluminum piston close enough to prevent slapping and still leave clearance enough for an oil film to separate the piston and the cylinder has been solved in several ways. (Piston slap is caused by the piston tipping from side to side in the cylinder.)

In a split skirt piston, skirt is either partially or in some cases, completely split. When the piston warms and begins to expand, it cannot bind in the cylinder since the skirt merely closes the split (Figure 1.10-A)

The T-slot piston is another variation of the split skirt. The top of the T tends to retard the transfer of heat from the head to the skirt of the piston. The vertical slot allows the skirt of the piston to close in when heated (Figure 1.10-B).

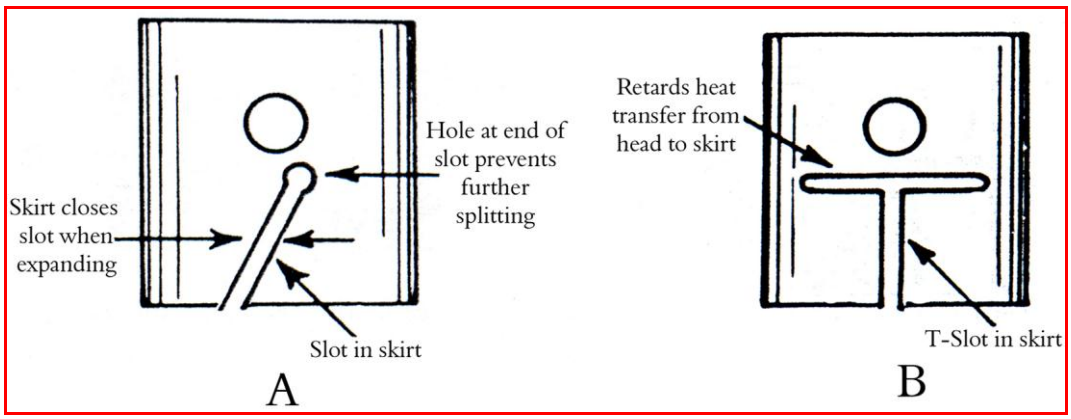

Figure 1.10: Split skirt and T-slot

- **Connecting Rod**

  The connecting rod connects a piston to a crankpin on the crankshaft. It converts the reciprocating motion of the piston to the continuous rotary motion of the crankshaft.

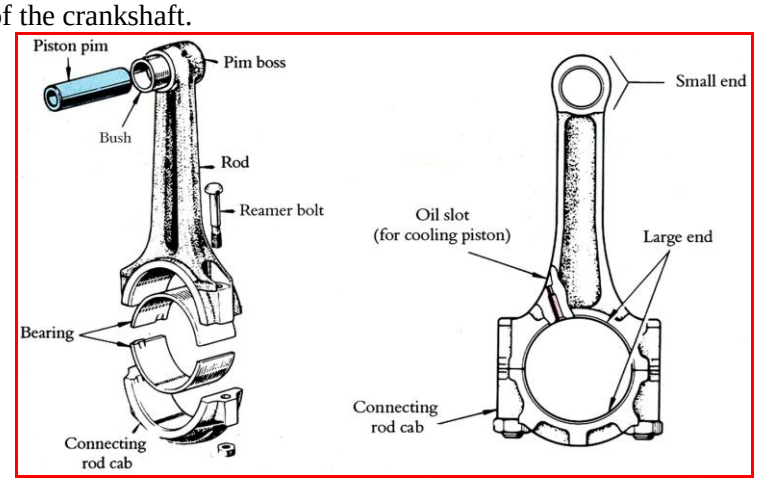

Figure 1.11: Description of each part of connecting rod

As the name implies, connecting rods are used to connect, pistons to the crankshaft.

The upper end of a rod oscillates (swings back and forth), while the lower or big end is bearing rotates (Figure 1.12).

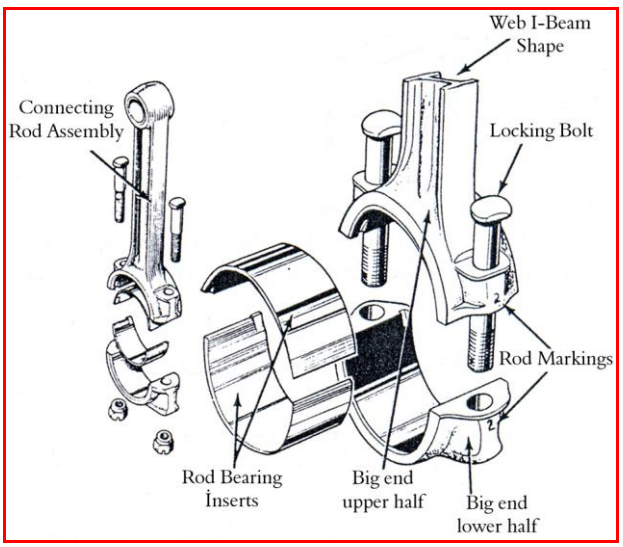

Figure 1.12: Typical connecting rod construction

As there is very little bearing movement in the upper end, the bearing area can be reasonably small. The lower (big) end rotates very fast, and the crankshaft journal turns inside the connecting rod. This rotational speed tends to produce heat and wear. To make the rod wear well, a larger bearing area is required.

The upper end of the rod has a hole through it for the piston pin. The lower end must be installed on the crankshaft journal.

The upper and lower halves of the rod are bolted together. The upper and lower halves should be numbered and when installed, the numbers should be on the same side. This prevents turning the cap around when installing the rod.

Connecting rods are generally made of alloy steel. They are drop-forged to shape, then machine. The customary shape utilizes I-beam construction (Figure 1.12).

Some rods are built of aluminum. Generally these are for small engines designed for light duty. Small engines often utilize the rod material for both upper and lower bearing surfaces. Special aluminum rods for high speed, high performance engines can be purchased from special machine shops.

➢ **Piston Pin**

The piston is attached to the small end of the connecting rod by means of a piston pin. The pin passes through the small end of the connecting rod and the bosses in the piston, thus transmitting the thrust power of the piston to be connecting rod.

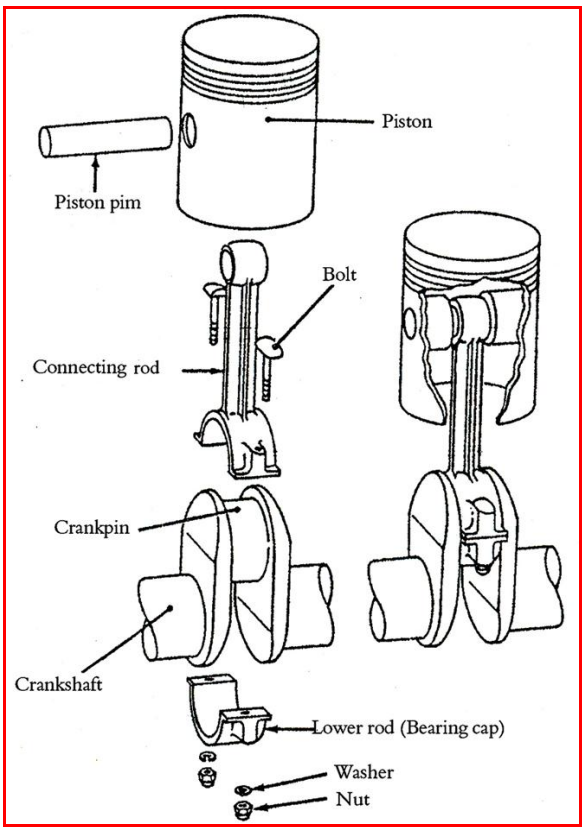

Figure 1.13: Connecting piston and connecting rod

➢ **Methods of Connecting Piston and Connecting Rod**

- Locked type

The piston pin is locked to the piston by means of a screw.

- Semi-floating type

For this type, locking the piston pin is not sufficient because while the piston is made of a light alloy with sufficient high thermal-expansion, the pin is made of steel. Therefore, the latter will become loose when it is hot if it is merely locked.

- **Bolt type** **:** The piston pin is bolted to the connecting rod.
- **Press-fit type** **:** The piston pin is fitted to the connecting rod with some interference by applying a pressure of 4.9 to 14.7 kN

- **Full-floating type**

The piston pin is locked neither to the piston nor to the connecting rod.

➢ **Piston Rings**

There is a clearance of 0.03 to 0.06 mm (0.012 to 0.004 in) between the piston and the cylinder. If the skirt has a 0.03 to 0.06 mm clearance and the head 0.08 to 0.10 mm, it is obvious that the piston cannot seal the cylinder effectively (Figure 1.14).

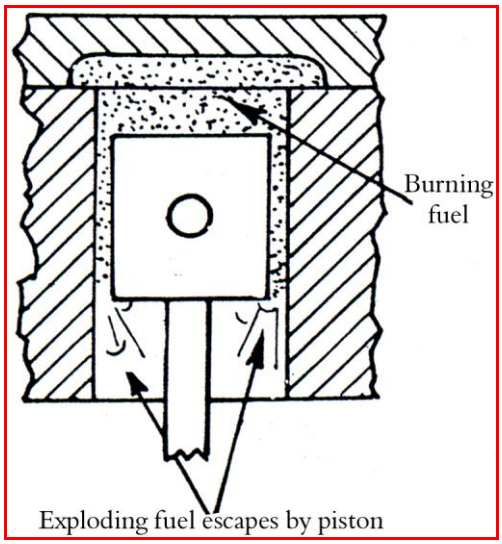

Figure 1.14: Piston cannot seal by itself because clearance with cylinder wall must be maintained

Piston rings provide the necessary seal of this clearance so that the compressed fuel charge and/or high-pressure burned gases will not escape from the combustion chamber into the crankcase. In addition, they serve to adjust the film of oil on the cylinder wall. The two upper rings are called compression rings which prevent the escape of burned gases and function as a heat passage for cooling the piston. The lowest ring is called an oil-control ring which scrapes off excess oil remaining on the cylinder wall.

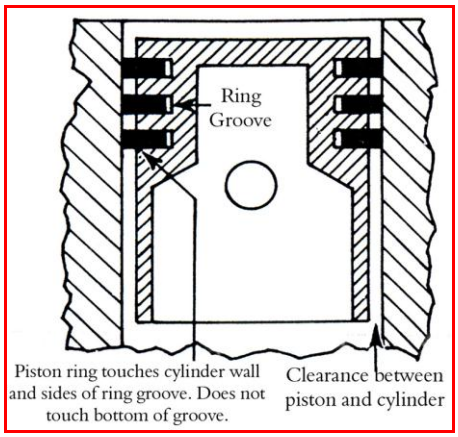

Figure 1.15: Piston rings seal gap between piston and cylinder wall

The solution to the leakage problem is the use of piston rings. A properly constructed and fitted ring will rub against the cylinder wall with good contact all around the cylinder. The ring will ride in grooves that are cut into the piston head. The sides of the ring will fit the edges of the grooves quite closely. This side clearance can be around 0.05 mm.

The rings will not contact the bottom of the ring grooves. Actually then, the ring will rub the cylinder wall at all times but will not be solidly fastened to the piston at any point (Figure 1.15).

- **Ring Gap**
  The ring is built so it must be squeezed together to place it in the cylinder. This will cause the ring to exert an outward pressure, thus keeping it tightly against the cylinder wall (Figure 1.16-A).

The ring is not solid all the way around but is cut through in one spot. This cut spot forms what is called the ring gap (Figure 1.16-B).

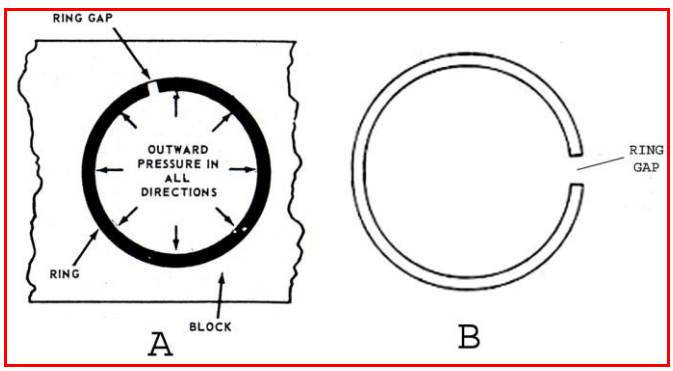

Figure 1.16: Top view of cylinder shows sealing action of piston ring

When the ring is in the cylinder, the cut ends must not touch. When the ring heats up, it will lengthen. Since it cannot expand outwardly, it will close the gap. If there is not enough gap clearance, the ends will soon touch and as the ring continues to lengthen, it will break up into several places. This can ruin a good engine.

A general rule for ring gap clearance is to allow 0.07 to 0.10 per mm of cylinder diameter.

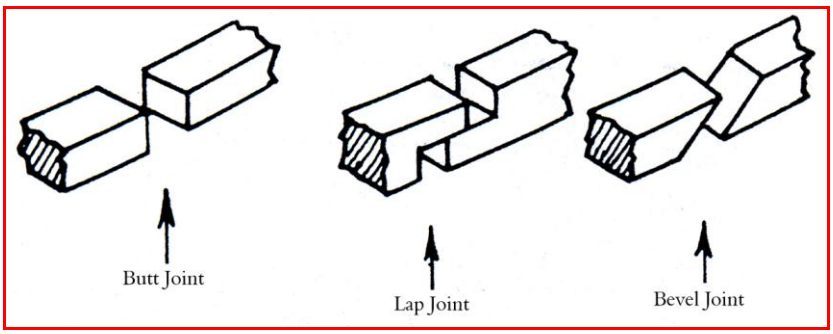

Figure 1.17: Types of piston ring gap joints

Many different types of joints have been used in an endeavor to stop leakage through the ring gap. This leakage is commonly referred to as blow by. It has been found that the common butt joint is about as effective as any and is much simpler to adjust (Figure 1.17) illustrates a few of the types of joints that have been used.

The ring is placed in the groove by expanding it out until it will slip over the piston head and slide down and into the ring groove.

- **Types of Rings**

There are two distinct types of rings. One is called a compression ring and the other an oil control ring.

Most engines use three rings on each piston; two compression rings and one oil control ring. Others use two compression rings and two oil rings. Some diesel engines use five or more rings.

All rings may be above the piston pin; or a second oil control ring may be set into a groove near the bottom of the skirt. The compression rings are always used in the top grooves and the oil control rings in the lower grooves (Figure 1.18)

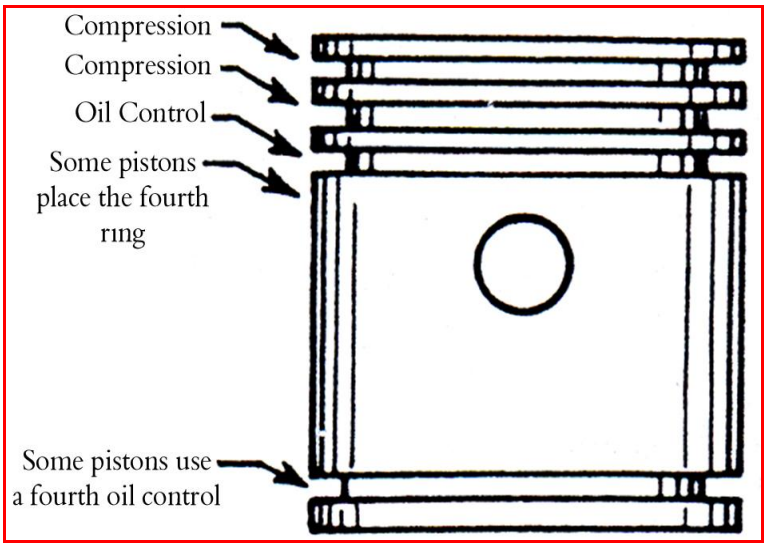

Figure 1.18: Location of compression and oil control rings

- **Compression Rings**

Compression rings are designed to prevent leakage between the piston and the cylinder (Figure 1.19).

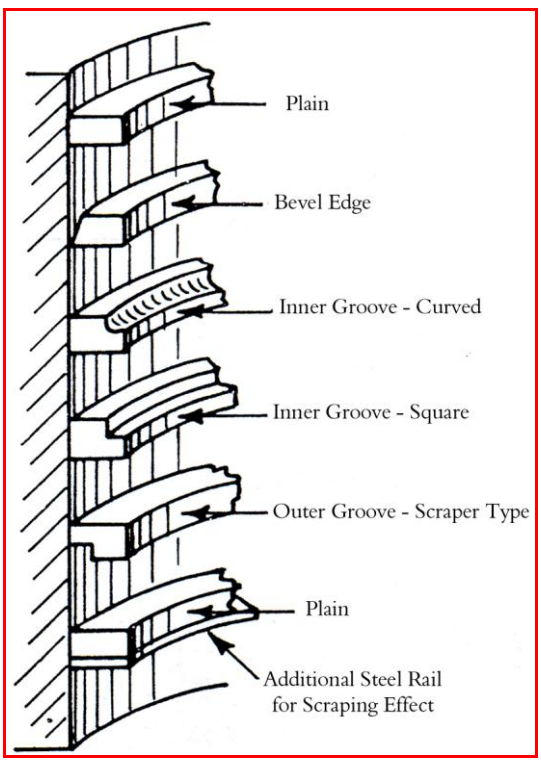

Figure 1.19 Typical compression ring shape, as they would look in a cylinder

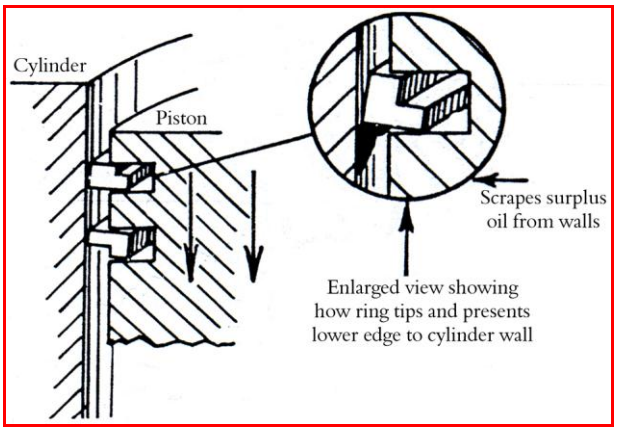

Figure 1.20 Internal stress causes rings to tip and act as mild scrapers

Various shapes are used to achieve this goal (Figure 1.19). The idea behind the various grooves, bevels and chamfers is to create an internal stress within the ring. This stress will tend to force the ring to twist in such a fashion as to press the lower edge to the cylinder wall on the intake stroke. This will cause the ring to act as a mild scraper. The scraping effect will tend to assist in the removal of any surplus oil that may have escaped the oil control ring (Figure 1.20).

On compression and exhaust strokes, the rings will tend to slip lightly over the oil film. This will prolong the life of the ring (Fig. 1.21).

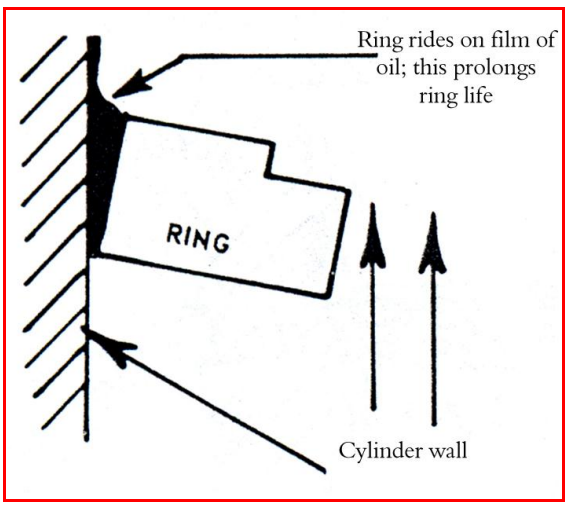

Figure 1.21: On compression and exhaust strokes rings tip and slide easily on a film of oil.

On the firing stroke, pressure of the burning gases will force the top edges of the ring downward. This causes the ring to rub the wall with full face contact and to provide a good seal for the enormous pressure generated by the firing stroke (Figure 1.22).

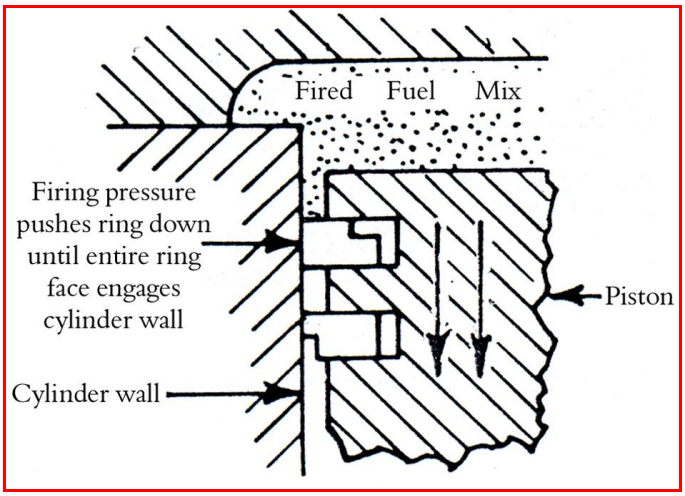

Figure 1.22 Firing pressure forces ring face against wall to provide a good seal

- **Oil Control Ring**

The oil control ring is used to scrape the surplus oil from the cylinder walls. This is not an easy task and much time and money has gone into the design and construction of oil rings (Figure 1.23).

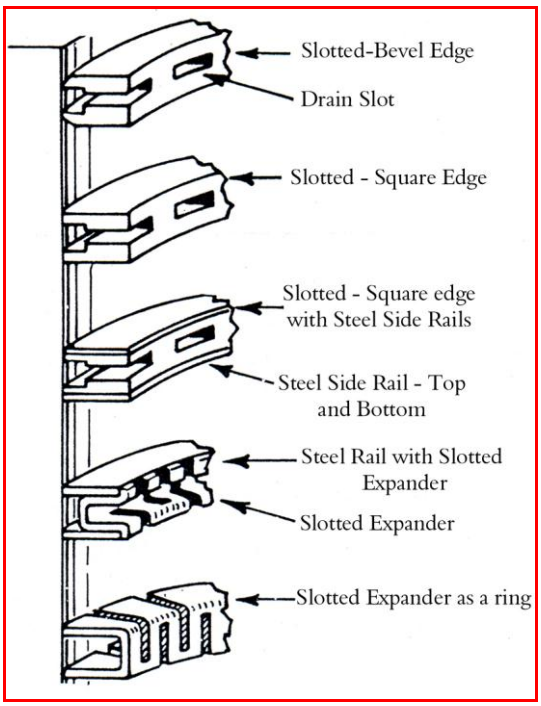

Figure 1.23: Common types of oil control rings

All oil rings are slotted and have scraping edges designed to scrape the surplus oil from the cylinder walls. The oil between scrapers passes through slots in the ring on through slots or drilled holes in the bottom of the ring groove. From there the oil drips down into the crankcase area (Figure 1.24).

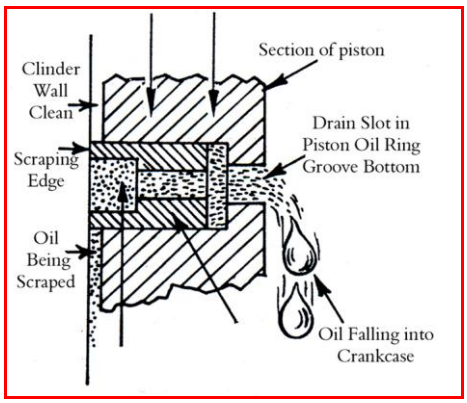

Figure 1.24: Action of oil ring as it travels down cylinder well

➢ Crankshaft

As combustion pressure is applied to the piston, it moves up and down inside the cylinder. This up-and-down motion or reciprocating motion is changed to rotary motion by means of the crankshaft and connecting rods. In other words, the downward power thrusts when act on the pistons are converted to engine torque by the crankshaft.

- **How does the crankshaft work?**

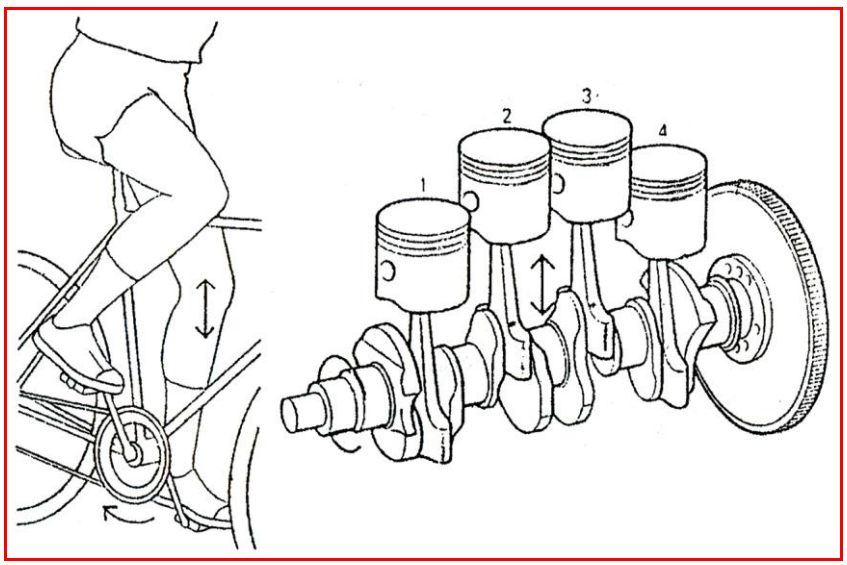

Figure 1.25: How the crankshaft works

Crankshaft converts reciprocating motion to rotary motion. Cyclist (Fig 1.25) demonstrates how a bike's pedals and crank convert the up-and-down motion of the rider's legs into the rotary motion of the sprocket wheels. Similarly the connecting rods and crankshaft (above) convert the up-and-down motion of the pistons and connecting rods into rotary motion. On this four-cylinder crankshaft, the two pistons at the top of their strokes (2 and 3) are balanced by two at the bottom of their strokes (1 and 4)

- **Crankpin**
  The crankpin of the crankshaft is attached to a connecting rod by a bearing shell and it receives direct combustion pressure.
- **Crank Arm**
  The part located midway between the crankshaft and the crankpin is called a crank arm. The stroke of the piston is twice the length of the crank arm. Therefore, if the engine uses a longer piston stroke, the crank arm becomes longer.
- **Crank Journal**
  This part is supported on the cylinder block by means of a bearing. In order to shorten the overall length of the engine, it is preferable to use a fewer bearings. However, if more bearings are installed it will be of great advantage to reduce undue vibration and increase durability.

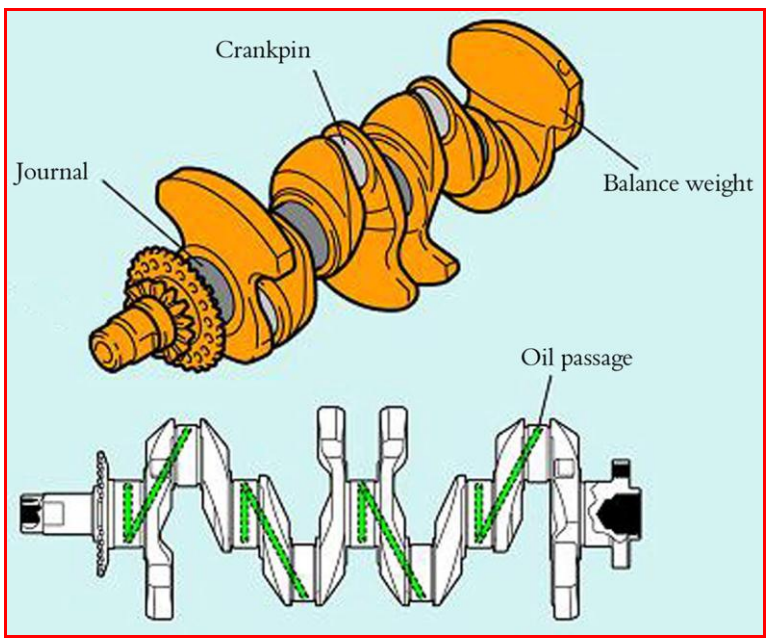

Figure 1.26: Parts of crankshaft

- **Balance weight**
  The portion of balance weights form part of the *crankshaft* which are designed to balance the inertia of the piston and the connecting rod reciprocating part as well as the centrifugal force of the crankpins. This

allows the engine to run more smoothly and reduces wear on the crank journal and bearings.

- **Oil Passage**
  There are oil passages drilled in the crankshaft running from the crankshaft journal to each crankpin through which pressurized lubricating oil can flow to lubricate the bearing shells which are located in the crank journal and crankpins.

➢ **The Valve Mechanism**

- **Function of Valve**
  During the operation of a 4-cycle engine, the intake valve draws in air-fuel mixture with the piston on its suction stroke and the exhaust valve expels the burned gases with the piston on its exhaust stroke. In short, these valves serve as the lids for each intake and exhaust port and they must perform the following functions:
  - When close, valves must provide a tight seal in order to prevent any leakage of the mixture or burned gases.
  - When open, they should allow the mixture or burned gases to pass through with a minimum of flow resistance or otherwise the engine performance will decrease considerably.
  - They must be able to withstand high temperatures since they are attached to the combustion chamber and therefore are exposed to the extremely hot burning gases when the mixture burns. The exhaust valve must especially be able to withstand exhaust gases reaching 800°C (1.472 °F) or hider passing through it.

- **Function of Valve Mechanism**
  The valve mechanisms cause the intake and exhaust valves to open and close and they must meet the following requirements:

1. Proper Valve Operation

In the 4-cycle engine, engine performance is greatly affected by where and when the intake and exhaust valves open and/or close on the four strokes. (Valve timing is detailed in the respective section of "C")

2. Sufficient Strength and Durability

Both the intake and exhaust valves must have sufficient strength and durability. This is because for example they must open and close repeatedly 2.000 times per minute when the engine is running at 4.000 rpm.

- **The Types of Valve Mechanism**

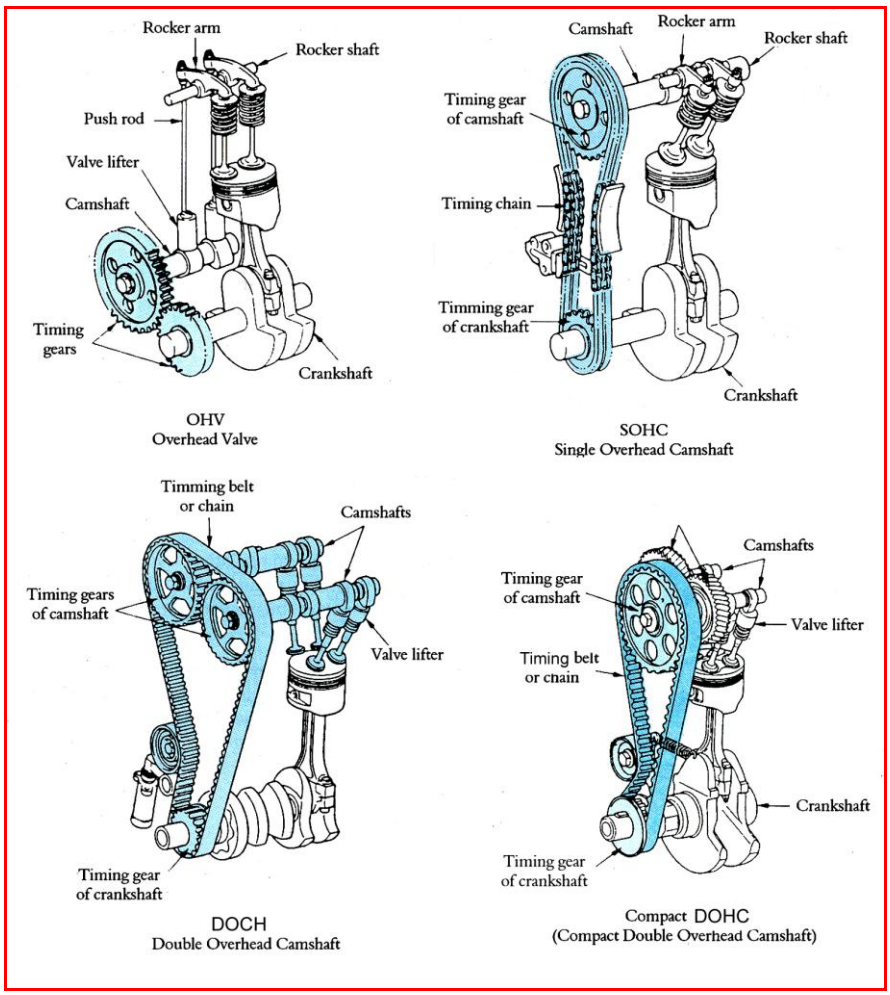

Figure 1.27: The type of valve mechanism

- **Parts of valve mechanism**

  The valves in some engines rub against hardened inserts called the valve guide and valve seal. Most combustion heat is passed from the valve to the water passages via the seat when the valve's closed. A worn valve guide will allow oil to be sucked into the combustion chamber. A damaged seal may lower the cylinder's compression (Figure 1.28).

  Rocker arms on many cars are made of pressed steel. These GM arms pivot on ball studs instead shafts.

  Valve Operation: As the cam rotates, it lifts the lappet and pushrod, pivots the rocker arm, and opens the valve (Figure 1.29-A). Further cam rotation allows the tappet and pushrod to fall and the spring to close the

valve (Figure 1.29-B). This design with the camshaft in the cylinder block is called an overhead-valve pushrod engine.

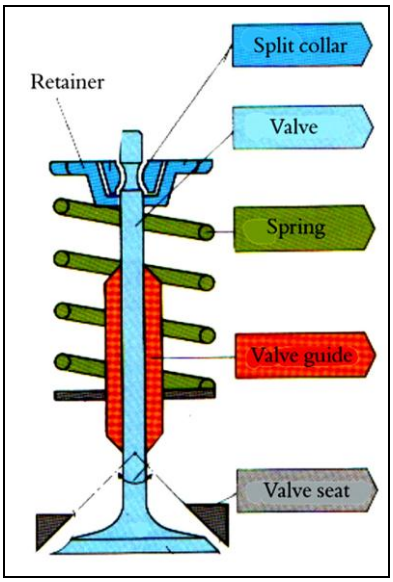

Figure 1.28: Parts of valve system

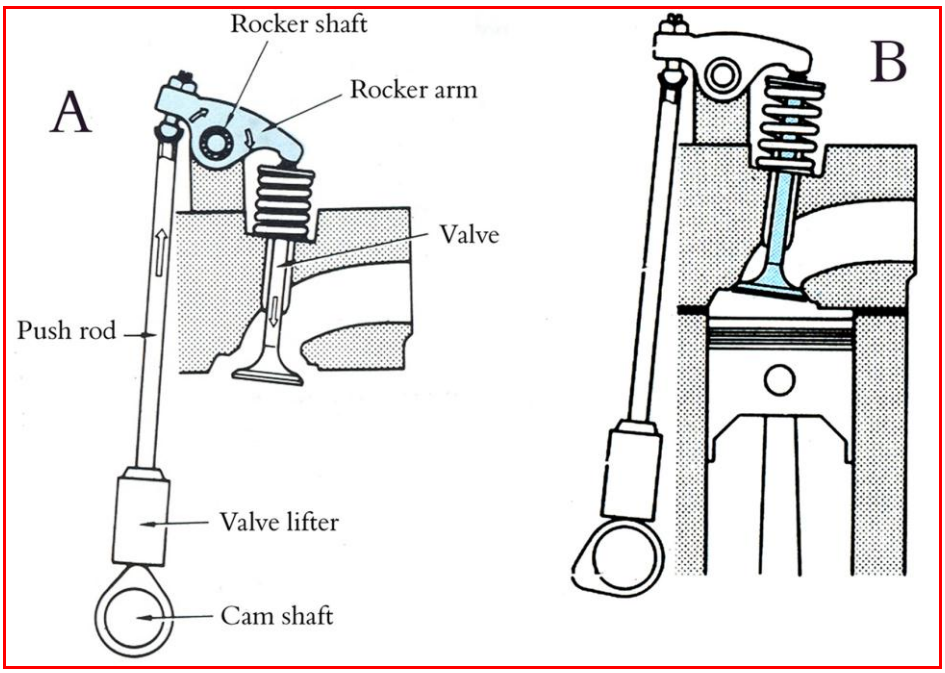

Figure 1.29: Valve operation

Hydraulic Lifters vary their height to maintain zero valve clearance at all times. When the lifter is down (left), pressurized oil flows past a check valve and fills the lifter. As

the cam raises the lifter (right), oil is trapped below the check valve and the lifter rises like a solid unit. When the lifter drops, oil leaks out so that the valve can close completely.

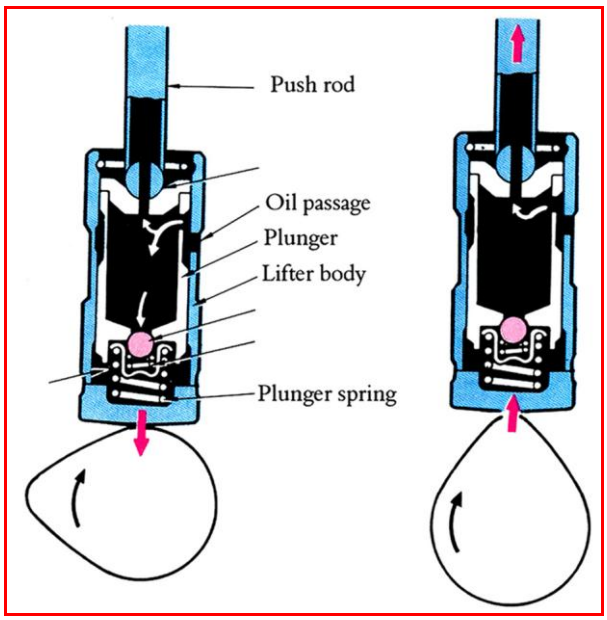

Figure 1.30: Hydraulic lifters

- **Camshaft**

  The camshaft is driven by the crankshaft at ½ the speed of the crankshaft for opening and closing the intake and exhaust valves. It consists of the following parts:

  - Oil pump drive gear: Drives the oil pump
  - Distributor drive gear: Drives the distributor
  - Fuel pump drive cam: Drives the fuel pump
  - Journal: Supports the camshaft
  - Cams: Open and close the intake and exhaust valves

- **Valve Clearance Adjustment**

  The valve clearance must be set when the cam follower is on the back of the cam. This ensures that the valve is fully closed. This position may be determined by rotating the crankshaft through one full revolution from the fully open position of the valve. There are various methods of operating overhead valves and the method of adjustment of the valve clearance depends upon the arrangement employed. If the conventional pushrod and rocker arm assembly are used, adjustment is usually by setscrew and locknut. Measurement of the valve clearance is generally made with a feeler gauge of the recommended size inserted between the top of the valve stem and the rocker arm as illustrated in Figure 1.39. If the feeler gauge will not go between the valve stem and the rocker arm, the locknut should be released and the setscrew slackened. Alternatively, if excessive clearance exists, the setscrew should be tightened.

The clearance is correct when it is just possible to enter the feeler gauge blade of the correct thickness between the valve stem and the rocker arm.

Some manufacturers give specifications for adjusting the valve clearance when the engine is operating at normal temperature and at a slow idle speed. The feeler gauge is inserted between the valve stem and the rocker while the engine is in operation. Adjustments are then carried out in a similar manner to those described in the above. This is probably the most accurate method of adjusting valve clearances although there are practical problems which can make the procedure somewhat difficult.

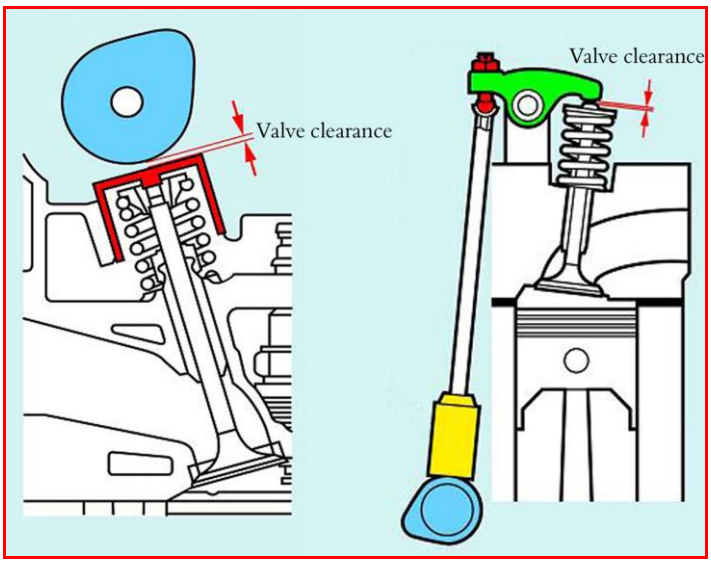

Figure 1.31: Valve clearance

- **Flywheel**

  The flywheel absorbs energy from the engine during the power stroke, and then returns it to the engine during the other three strokes of the cycle. Therefore the larger the flywheel, the more effectively it will operate to reduce changes in revolving speed or torque variation. However, if the flywheel is too large, a substantial turning force will be required to start the engine; also, the engine will provide reduced acceleration performance; and finally, there will be an increase in vehicle weight. For these reasons, it is preferable to keep the flywheel as light as possible**.**

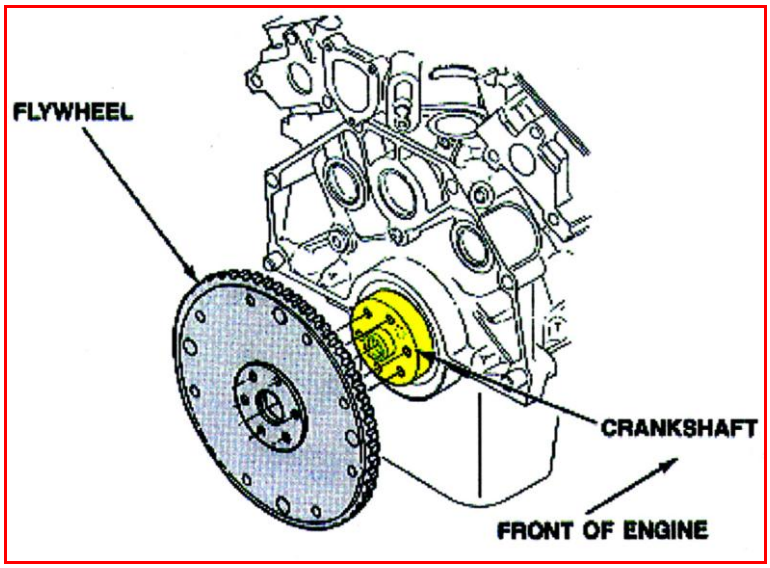

Figure 1.32: Flywheel assemble

1.4. The Running Principle of the Automotive Engines

1.4.1. Four Cycle Diesel Engine

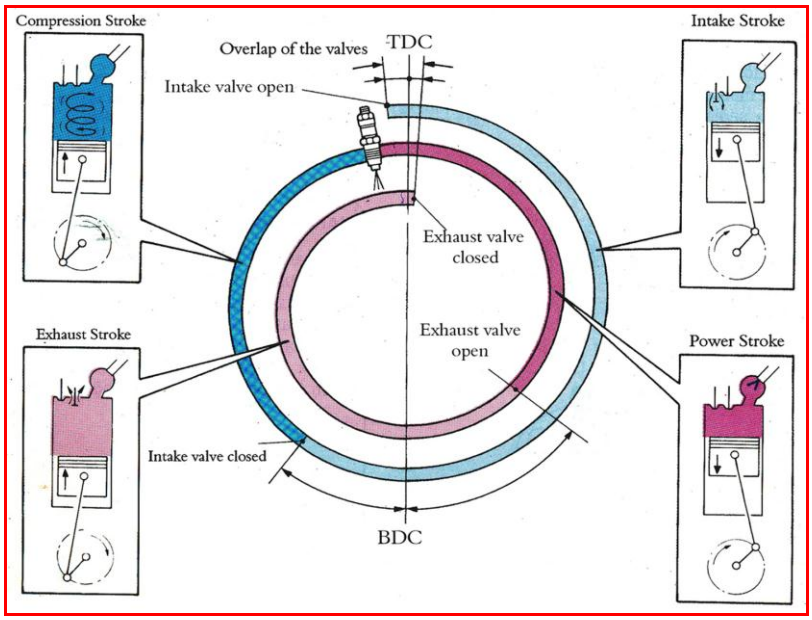

Figure 1.33: Running principle of the four-cylinder diesel engine

- **Induction Stroke**
  The inlet valve opens and the piston moves downward, a depression is created in the cylinder. Atmospheric pressure outside the cylinder forces air through the open inlet port into the cylinder, as in Figure 1.33. Once the piston has reached the end of the induction stroke the inlet valve is closed.

Note : Only air is drawn into the engine as there is no carburetor and the air intake is not throttled or obstructed in any way.

- **Compression Stroke**
  The piston moves upwards, both inlet and exhaust valve remain closed, and the air trapped in the cylinder is compressed to approximately one-sixteenth of its original volume, as indicated in Figure 1.33. The actual compression ratio used varies from engine to engine from approximately 12:1 to 23:1 or in some applications even higher. As a result of the high pressure the air temperature within the cylinder will be about 800°C (1500°F). A measured quantity of atomized fuel is injected into the cylinder just before the piston reaches the top of its stroke.

- **Power Stroke**
  The injected fuel has a self-ignition temperature in the region of 400°C (752°F), therefore, being introduced into a temperature or 800°C, it ignites and begins to burn. The expansion of the burning gases forces the piston down on its power stroke, as shown in Figure 1.33.

- **Exhaust Stroke**
  As the piston nears the end of its downward stroke, the exhaust valve opens. The spent exhaust gases are forced out of the cylinder as the piston moves upward on its exhaust stroke as illustrated in Figure 1.33. When the piston reaches the top of its travel the exhaust valve is closed and the inlet valve opens and another cycle of operations begins.

1.4.2. Four Cycle Gasoline Engine

- **Induction Stroke**
  In the first half turn of the crankshaft the piston is drawn down the cylinder. At the same time the inlet valve is opened and a mixture of air and petrol is drawn into the cylinder by the descending piston. The induction stroke is shown in Figure 1.34. Just after the piston has reached the end of the induction stroke the inlet valve is closed. At this point the mixture of air and petrol is sealed in the cylinder.

- **Compression Stroke**
  On the next half turn of the crankshaft both inlet and exhaust valve remain closed. The piston moves upward, compressing the mixture of air and petrol into the small space above the piston which is called the combustion chamber. When the piston has reached the top of its stroke, a large quantity of gas is

tightly packed into a small space. At the end of the compression stroke, a high voltage is made to jump across the gap of the sparking plug, causing the compressed mixture affair and fuel to burn. The compression stroke is illustrated in Figure 1.34.

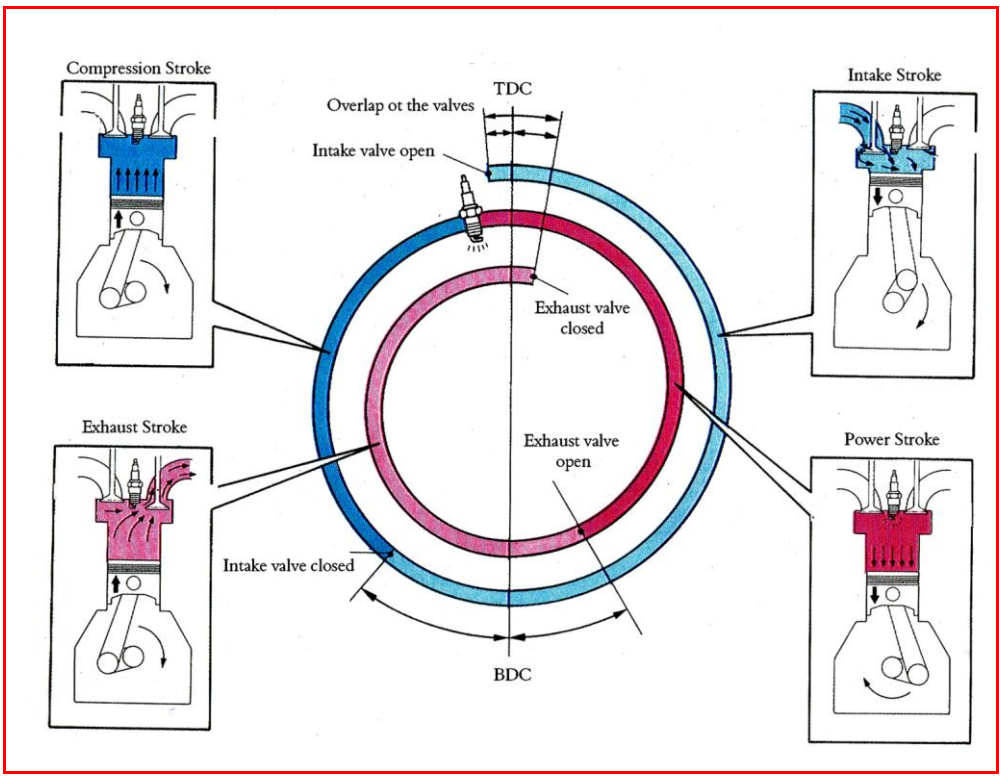

Figure 1.34: Running principle of the four-cylinder Otto (gasoline) engine

- **Power Stroke**

  Immediately the compression stroke is completed, the mixture in the cylinder is ignited by the sparking plug. The burning and expansion of the gases is so rapid that the piston is forced down the cylinder again, as shown in Figure 1.34. It is this stroke which gives the engine its power. The power with which the piston is forced down the cylinder during this stroke must cause the flywheel to travel with at least sufficient speed and force to enable the piston to move up and down the cylinder until the next power stroke is performed. Obviously, the more petrol vapor and air which is allowed into the cylinder, the greater will the burning and expansion be, and consequently the power of the stroke and the speed of the vehicle. When the piston is approaching the bottom of the power stroke, the exhaust valve is opened, thereby allowing the burnt gas to escape from the cylinder.

- **Exhaust Stroke**
  With the exhaust valve already well open, the piston moves up the cylinder, sweeping the burnt gases before it as indicated in Figure 1.34. However, it is impossible to expel all the burnt gas for when the piston reaches the top of its stroke the contents of the combustion chamber still remain. When the piston reaches this position, it will be ready to descend on another induction stroke. The comp1ete sequence of events has now been described induction, compression, power and exhaust making up one complete cycle of operation.

1.5. Systems of the Automotive Engines

1.5.1. The Lubrication System

All moving components of a modern engine operate at high temperatures and at high speeds and most of these components are subjected to very high pressures. Lubrication is therefore necessary to avoid excessive wear corrosion and contamination and thus to ensure a long life for the engine.

A pump forces the lubricant through the various components by means of appropriate ducts. The efficiency in evacuating the calories is function of the pressure, the flow of the pump, the diameter of the ducts.

- **Function of Lubricating Oil**

  - **Wearing Resistance**
    Lubricates the moving parts and minimizes wear.
  - **Efficiency**
    Lubricates the moving parts thereby minimizing loss of output caused due to friction.
  - **Cooling**
    Eliminates heat of the moving parts.
  - **Reduction of noise**
    Absorbs shocks and reduces noise and extends
  - **Air tightness**
    Keeps moving parts' air tightness
  - **Cleaning**
    Cleans moving parts
  - **Rust prevention**
    Prevents formation of rust on each part

- **Lubrication**
  The purpose of lubricating is to prevent the friction of metallic surfaces, putting a layer of lubricant between them
  Since the oil is in contact with hot parts, it serves also to eliminate part of the calories thus helping to cool the engine.

➢ **Characteristics of Lubricating Oil**

Lubricating oil is refined from petroleum; its major component is base oil which is refined from the gas left after evaporation of gasoline light oil and other oils. To improve the characteristics of this base oil and make it suitable for automotive use, a variety of additives are used. Lubricating oil is used for the following purpose:

- to reduce wear
- to improve efficiency
- to cool
- to reduce noise
- to maintain air tightness
- to clean
- to prevent rust

➢ **Passages of Lubricating Oil**

Lubricating oil under regulated pressure is sent from the oil pump driven by the cam or crankshaft gear to the oil filter, where it is cleaned before being sent into the main gallery. The oil is then distributed to the crankshaft journals, crankpins, and then to the camshaft journals and rocker arms on the cylinder head where it performs lubrication. Remaining oil is returned to the oil pan. When the oil pressure rises the oil pressure switch is turned off and the oil warning lamp goes out

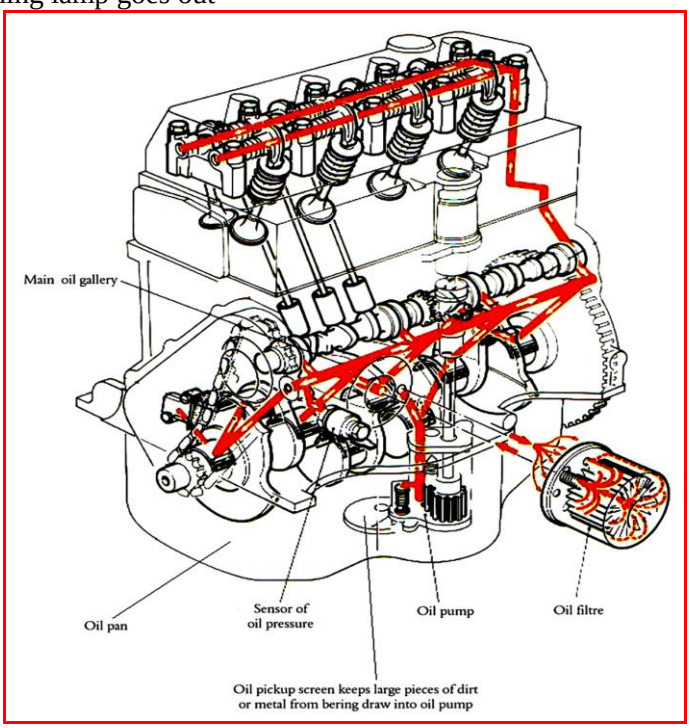

Figure1.35: Passages of lubricating oil

1.5.2. Cooling System

The burning of fuel in an internal combustion engine produces heat which is sufficient to melt the metal of the cylinder. It is the function of the cooling system to prevent the engine overheating but it must also allow it to operate at a temperature high enough to assist in effective combustion. If the engine operating temperature were allowed to go unchecked, it would burn and dry up the lubricating oil film, so that the pistons would seize in their cylinders and distortion would result from over-expansion of metals.

- **Functions**

The engine of an automotive vehicle runs with energy obtained from fuel combustion. Therefore the following situation will occur and the engine will not be capable of performing its functions unless the engine is kept suitably cooled while it is running.

- Oil burns and does not play a role in lubrication, resulting in seizure of pistons and valves.
- Hot spots from on the walls or combustion chambers, resulting in an abnormal combustion called are "surface ignition".
- Deformation of metal occurs due to thermal expansion and clearances are changed and there is fear of the occurrence of sticking.

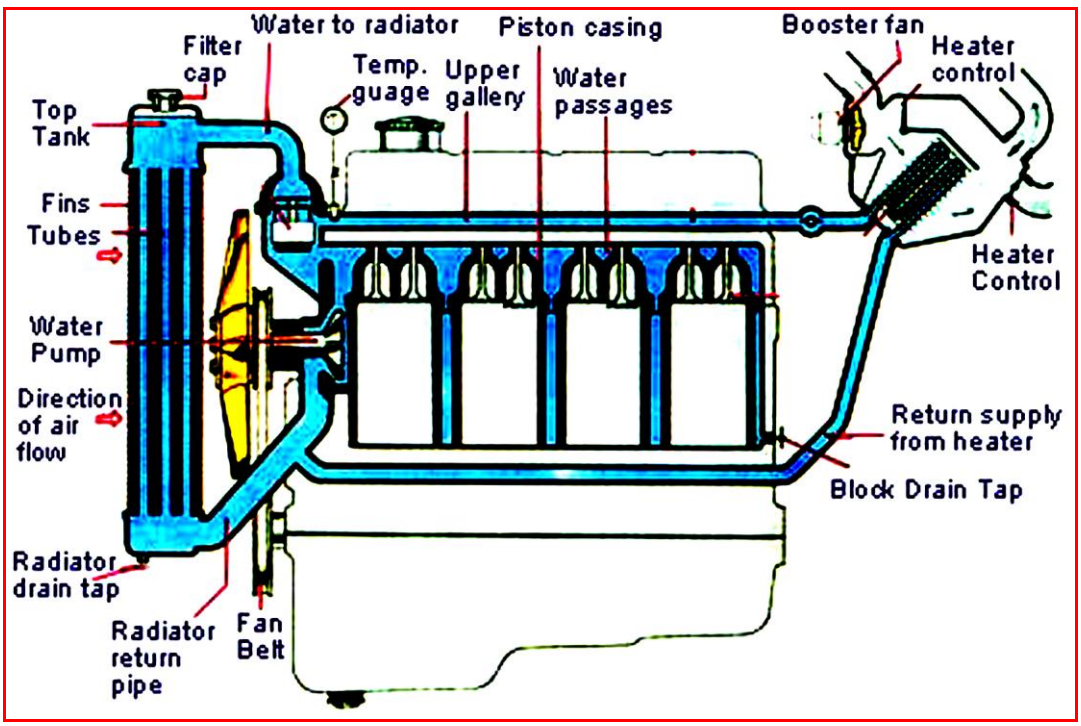

Figure 1.36: Water cooling system

Air cooling is not generally used for the larger and more highly rated high speed engines. It has however, become very popular with a number of European vehicle manufacturers, as the system has the merits of simplicity and freedom from the possible problems associated with water-cooled engines.

1.5.3. Ignition System

In a conventional ignition system, the breaker points act as a mechanical switch to turn the current flow through the coil on and off. Electronic ignition systems which use no mechanical devices are called transistors. A transistor can use a very small flow of current to switch a much larger flow of current. The various makes of electronic ignition differ mainly in the way this small current is generated in one of Chrysler's systems, a gear like reluctor turns with the distributor shaft. As each tooth of the reluctor passes a magnetic coil in the distributor, a small electric pulse is generated. This pulse switches the transistor on and off, cutting the flow of low-voltage current through the coil's primary winding.

Other systems use metal detectors, light-emitting diodes, or the hall affect to generate the small current needed to switch the transistor on and off.

Transistors have several advantages over mechanical breaker points: they have no moving parts that wear or require lubrication; they do not pit or bum; and they can switch higher voltages than points can. The capacity to switch high voltage into the coil enables a transistorized ignition system to produce higher voltage at the spark plug electrodes than a breaker-point system can. This higher voltage can jump a wide spark plug gap, creating the fat spark needed to ignite the lean air-fuel mixtures used in many modern engines without computer controls. A high-voltage spark will also fire a partially fouled spark plug.

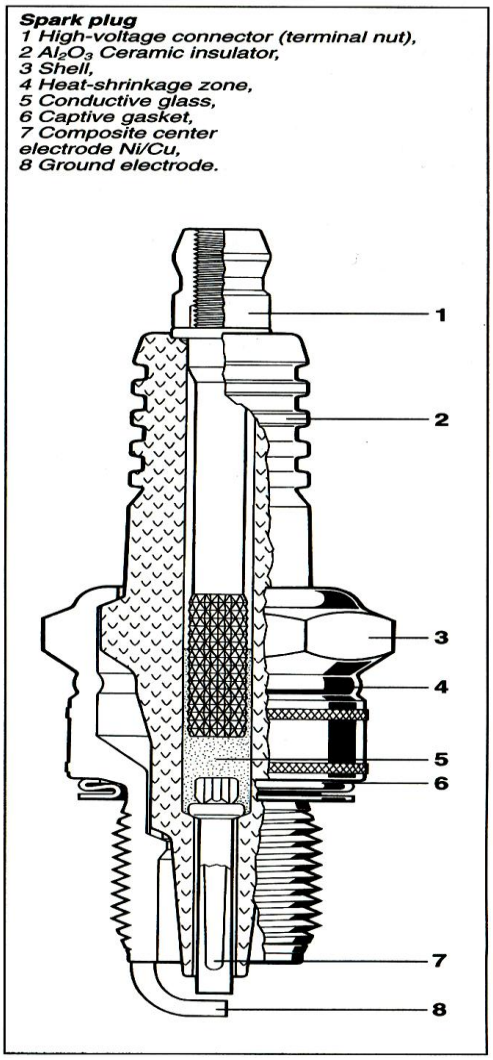

Figure 1.37: Spark plug

- **High-Voltage Generation And Energy Storage**

  Battery-ignition systems generally employ an ignition coil to generate the high tension voltage needed to ignite the spark plug. This coil functions as an autotransformer, and within coil-ignition systems it also assumes the other important function of storing the ignition energy. When the contact breaker closes, energy from the vehicle's electrical system flows into the coil's primary winding. This energy is then stored in a magnetic field until the firing point, when the secondary winding discharges it to one of the engine's spark plugs. The ignition coil is designed to transmit surplus energy, maintaining an adequate safety margin between the spark plug's maximum potential voltage requirement and the available high-tension current.

- **Ignition Timing And Adjustment**

  Approximately two milliseconds elapse between the mixture's initial ignition and its complete combustion. The ignition spark must therefore arc early enough to ensure optimum combustion pressure under all engine operating conditions. The chosen firing point should ensure that the following requirements are met:
  - Maximum engine performance
  - Low fuel consumption
  - No engine knock
  - Clean exhaust.

- **Ignition And Emissions**

  Owing to the fact that it directly affects the various exhaust-gas components, the ignition has a significant effect upon exhaust emissions. Because various -and in this context sometimes mutually antagonistic - factors such as fuel economy, drivability, etc, are also potential optimization criteria, it is not always possible to specify the ideal ignition timing for minimum emissions.

- **Spark plug**
  - **Function**

    The spark plug transfers the high-tension ignition voltage generated within the coil into the combustion chamber, where the arc that this voltage produces between the electrodes serves to ignite the air/fuel mixture. The spark plug thus plays a decisive role in ensuring reliable, optimal engine performance. These are especially vital factors with modern engine-management systems, where specially designed spark plugs are becoming increasingly significant.

  - **Design requirements**

    The spark plug must satisfy a variety of complex performance demands: It is exposed to variable periodic processes within the combustion chamber as well as external climatic conditions.

An essential electrical requirement is the ability to function at ignition voltages in excess of 30,000 V. with insulation remaining unimpaired at temperatures in the 1000°C range.

Because the spark plug is subjected to mechanical stresses in the form of exposure to periodic pressure peaks (up to 30 bars) within the combustion chamber, its materials must exhibit extreme resistance to thermal loads and continuous vibratory stress. Meanwhile, that section of the spark plug that protrudes into the combustion chamber is exposed to high-temperature chemical processes, making resistance to aggressive combustion deposits (high-temperature corrosion) essential. Another vital factor for reliable spark-plug performance is efficient thermal conductivity. Because it is subjected to rapid variations between the heat of the combustion gases and the cool air/fuel mixture, the ceramic insulator must display high

resistance to thermal stresses (thermal shock). Effective heat transfer at the electrodes and the insulator are also essential for reliable spark-plug performance.

- **Design Structure**
  An electrically-conductive, east-glass element forms the connection between a center electrode and terminal nut in a special high-grade ceramic insulator. This glass element acts as a mechanical support for the components while providing a gas seal against the high-pressure combustion gases. It can also incorporate resistor elements for interference suppression and bum-off. The connection end of the insulator is glazed for improved protection against contamination. The connection between it and the nickel-plated steel shell is gastight. The ground electrode, like the center electrode, is primarily manufactured using nickel-based alloys to cope with the high thermal stresses. It is welded to the shell. The thermal conduction properties of both the center and the ground electrodes are improved by using a nickel-alloy jacket material and a copper core. Silver and platinum, or platinum alloys, are employed as electrode material for special applications. The spark plugs have either a standard SAE thread, depending upon the type of high-voltage connection. Spark plugs with metal shields are available for watertight systems and for maximum interference suppression.

➢ **Types of Ignition Systems**

- **Conventional Coil Ignition (CI)**
  Many vehicles are still equipped with conventional coil ignition. When the contact breaker closes with the ignition switched on, current from the battery (alternator) flows through the ignition coil's primary winding, generating the powerful magnetic field in which the energy is stared. At the ignition point, the contact breaker interrupts the current, the magnetic field collapses, and the high voltage necessary for ignition is induced in the secondary winding. This voltage is fed from terminal 4 to the ignition distributor via a high tension cable, and from there to the individual spark plugs.

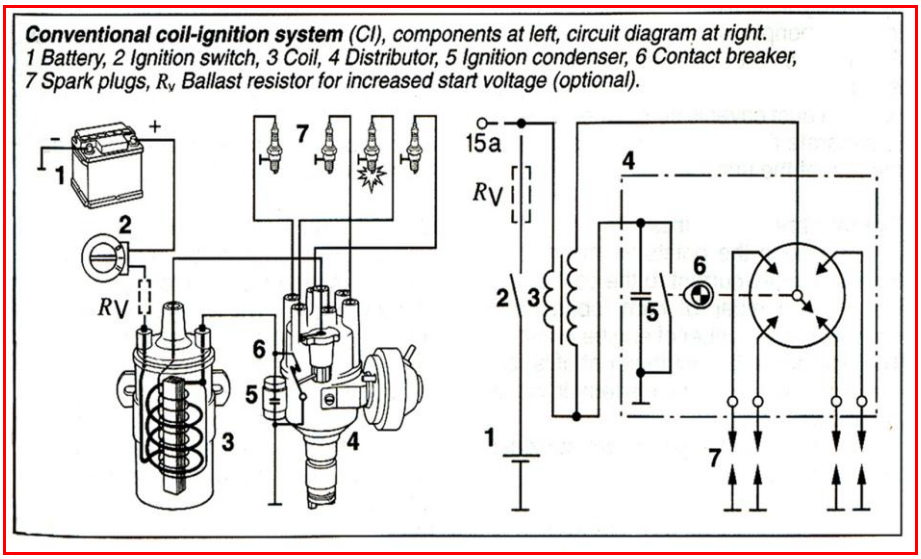

Figure 1.38: Conventional Coil-Ignition System

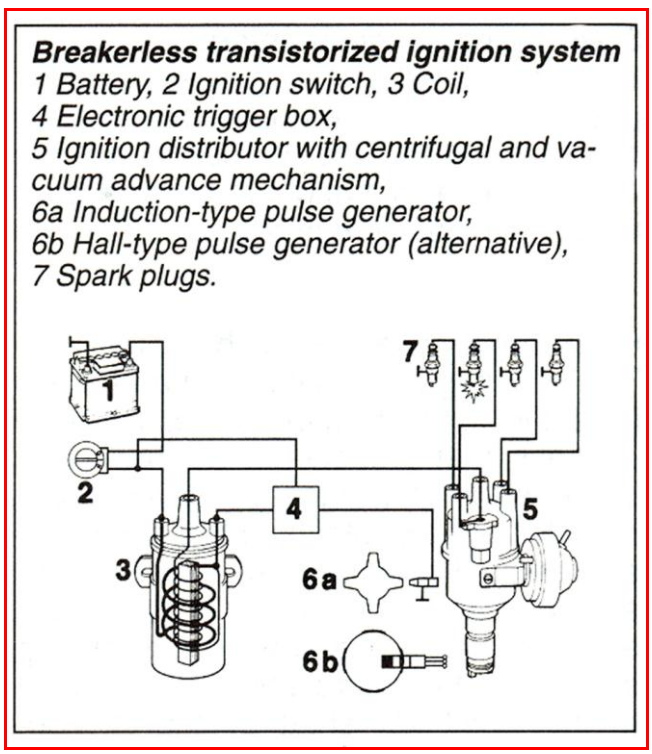

Figure 1.39: Breakerless Transistorized Ignition System

- **Transistorized ignition (TI)**
  With conventional coil-ignition systems, ignition energy and maximum voltage are restricted by various electrical and mechanical factors limiting the breaker points' switching capacity. The demands placed upon battery-ignition systems are often more than the contact breaker assembly can satisfy its role as a power switch. In electronic ignition systems, the points are assisted or replaced entirely by wear-tree control devices. Transistorized (coil) ignition is available in both breaker-triggered and breakerless versions.
  Transistorized coil ignition with contact control is especially suitable for upgrading existing coil-ignition systems (CI). Breaker-triggered transistorized coil ignition systems are no longer installed as original equipment.

- **Capacitor-discharge Ignition System (CDI)**
  The operating concept behind CDI, or "thyristor ignition" as it is also called, differs from that of the ignition systems described above. CDI was developed for use with high-speed, high-output multi-cylinder reciprocating IC engines in high-performance and competition applications and for rotary engines.
  The salient characteristic of the CDI system is that it stores ignition energy in the electrical field of a capacitor. Capacitance and charge voltage of the capacitor determine the amount of energy which is stored. The ignition transformer converts the primary voltage discharged from the capacitor to the required high voltage. Capacitor-discharge ignition is available in both breaker-triggered and breakerless versions.
  The major advantage of the CDI is that it generally remains impervious to electrical shunts in the high-voltage ignition circuit, especially those stemming from spark-plug contamination. For many applications, the spark duration of 0.1...0.3 ms is too brief to ensure that the air-fuel mixture will ignite reliably. Thus CDI is only designed for specific types of engine, and today its use is restricted to a limited application range, as transistorized ignition systems now afford virtually the same performance. CDI is not suited for after-market installations.
  CDI can also be employed for distributorless ignition with the installation of one ignition coil per cylinder, with energy distribution taking place at the medium-voltage level.

- **Electronic Ignition Systems (ESA and DU)**
  Electronic ignition derives its name from the fact that it calculates the ignition point electronically. The characteristic curves provided by the conventional distributor's centrifugal and vacuum-advance units are replaced by an optimized electronic ignition map. Mechanical high-tension distribution is retained with the ESA version of electronic ignition. Fully-electronic (distributorless) electronic ignition (DU) uses

stationary electronically-controlled components to replace the mechanical, rotating high-tension distributor.

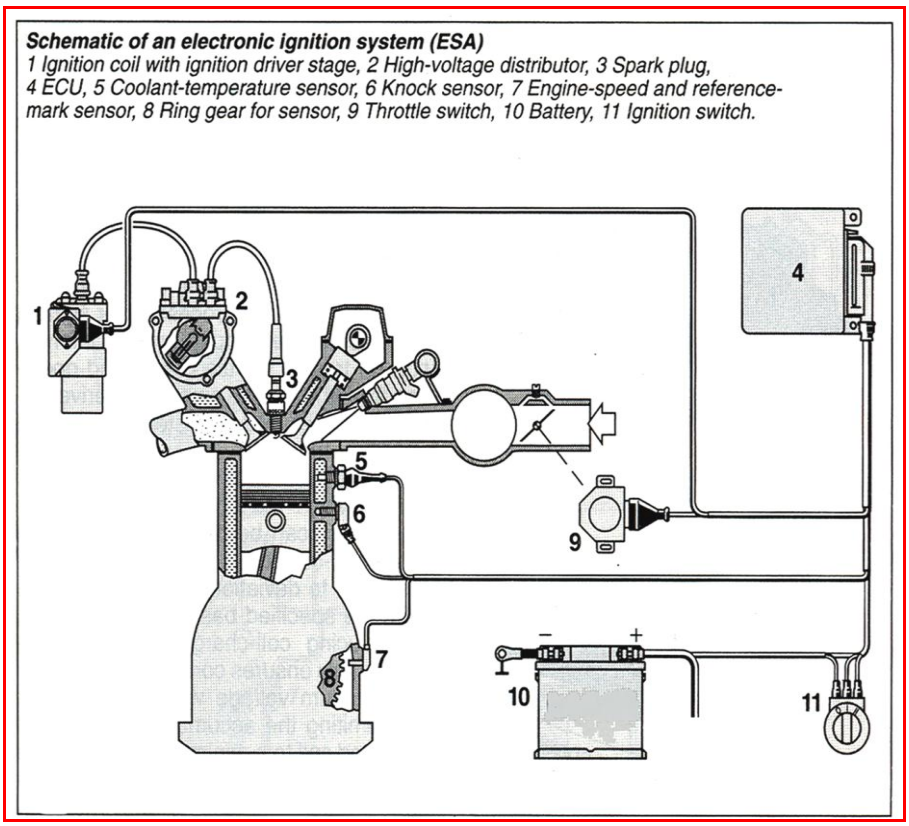

Figure 1.40: Schematic of an electronic ignition system

Electronic ignition systems operate more precisely than mechanical systems, with major benefits originating in the fact that the ignition process can be triggered from the crankshaft instead of from a distributor (distributor drive tolerances are no longer a factor). The limitations which mechanical adjustment mechanisms place upon the performance curve (summation of curves for load and engine speed in a single progression) are also avoided. The number of input variables is also theoretically unlimited, usually allowing extensions in the ignition angle's adjustment range. The fixed-drive ignition distributor's limitations regarding the engine's ignition-voltage requirements and ignition-angle adjustment range are such that it has difficulty coping with larger numbers of cylinders; efficient spark distribution cannot always be guaranteed. Corrective measures include dividing the ignition into two circuits (e.g., l or 8 and 12-cylinder engines) and static voltage distribution.

Electronic ignition can be combined with electronic fuel-injection (Motronic), knock control, ASR, etc., making it possible to employ sensors and/or signals from other units in more than one system. A serial bus further reduces the number of inputs and processing circuits on the ECU's input-side.

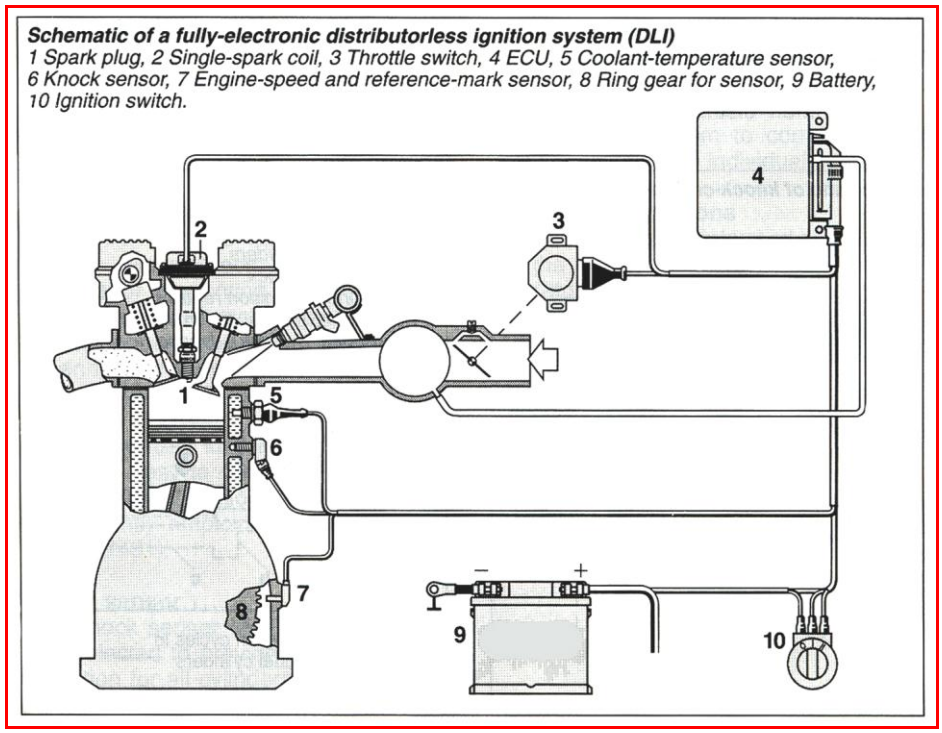

Figure 1.41: Schematic of a fully-electronic distributorless ignition system

1.5.4. Fuel System

- **Otto (Gasoline) Engine Fuel System**
  - **Fuel Management**

    Fuel management for the spark-ignition engine entails controlling the following functions to regulate the air-fuel mixture:
    - Metering it in the correct quantity and ratio
    - Its formation,
    - Its transportation,
    - Its distribution.

The driver-operated throttle valve regulates the mixture quantity, while the mixture-formation device controls the mixture ratio by metering the appropriate amount of fuel into the air being drawn into the engine.

Mixture formation is significantly influenced by the type of fuel-injection device. The fuel generally enters the intake manifold in droplet form. Some of the droplets evaporate to form fuel vapor on their way to the intake valves (desirable), while others form a film on the manifold walls (undesirable). Most of the improvement in mixture quality associated with single-point mixture formation is traceable to improved atomization at the throttle valve and enhanced evaporation on the warm walls of the intake manifold/heating elements. On

multipoint fuel-injection systems, excellent mixture formation at the injector is supplemented by evaporation on the hat intake valve.

With single-point mixture formation, mixture transport and mixture distribution both take place within the intake manifold. In consequence, the manifold's design has a major influence on both processes, and uniform mixture distribution under all operating conditions is very difficult to achieve.

With decentralized mixture formation, i.e., multipoint injection systems, pure air flows through most of the length of the intake tract. The fuel is generally injected directly before the intake valve to ensure optimum conditions for uniform mixture distribution.

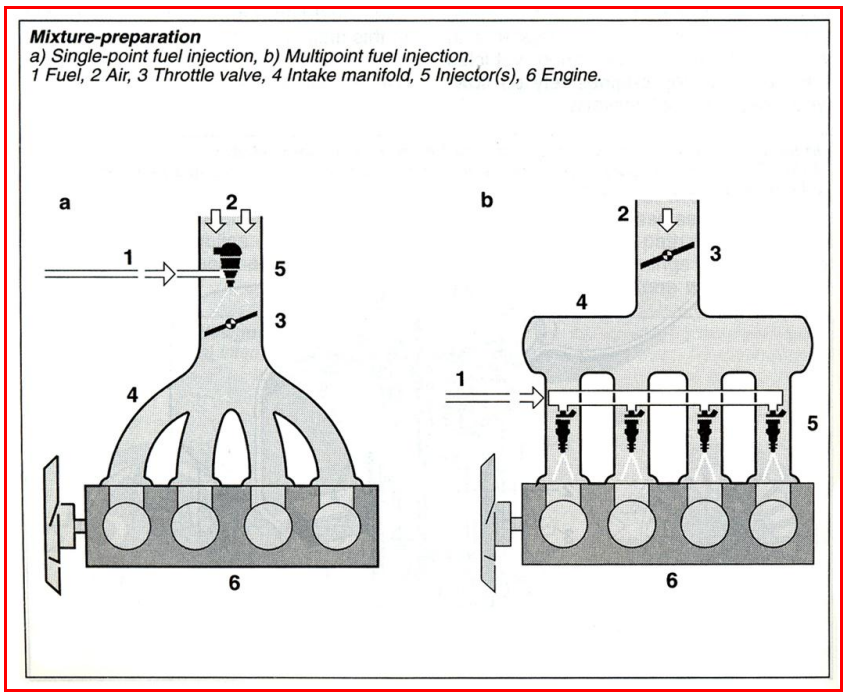

Figure 1.42: Mixture-Preparation

- **Carburetors**
  The fuel is transported from the fuel tank to the carburetor by a fuel pump (generally a diaphragm unit) powered by the camshaft or distributor shaft. The system is designed to limit the maximum supply pressure. A fine-mesh fuel filter can be installed upstream or downstream from the pump as required.

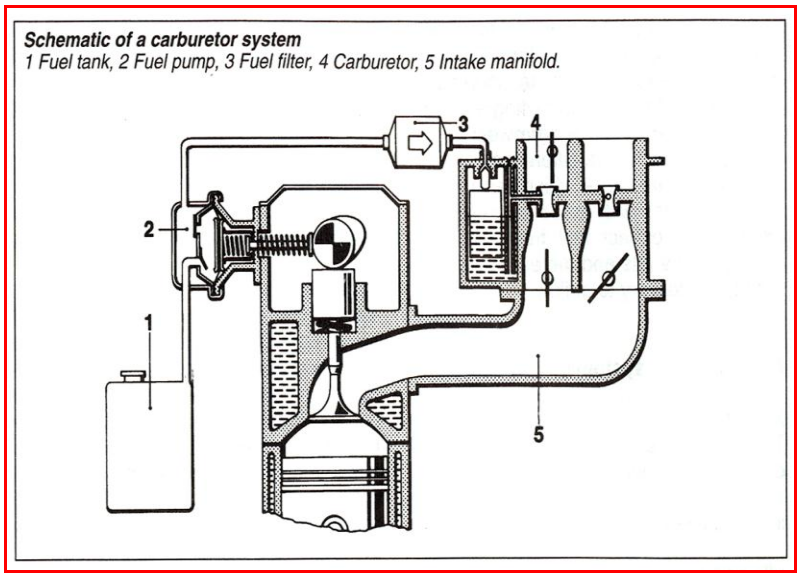

Figure 1.43: Schematic of a carburetor system

- **Carburetor Types**

Downdraft carburetors

Downdraft carburetors are the most common type. Designs featuring optimized float chamber and metering-jet configurations result in efficient units. These designs work in conjunction with the corresponding intake-manifold layouts for optimum mixture formation and distribution.

Side draft carburetors

Side draft carburetors (familiar as fixed venturi and constant-depression units) are useful for minimizing engine height.

Constant-depression carburetors feature venturi cross sections which vary in size during operation to maintain essentially constant vacuum levels at the fuel outlet. The variation in intake cross section is provided by a pneumatically-actuated plunger; attached to the plunger is a needle which regulates the fuel quantity.

Venturi configurations

The single-throat carburetor with one venturi is the cheapest design.

The two-stage carburetor featuring two venturis provides convenient tuning for individual applications and has become the standard in 4-cylinder applications. The first barrel controls part-throttle operation, while the second venturi opens for maximum performance.

The double-barrel carburetor features two carburetor sections sharing a single float chamber and operating in parallel, making it ideal for use on 6-cylinder engines. The two-stage four-barrel carburetor has four venturi fed from a single float chamber.

Type of Fuel-Injection Systems

Single –Point Fuel-Injection Systems

Single-point fuel injection has advanced beyond the compact fuel-injection system stage to become part of a comprehensive engine-management system.

The various single-point injection systems differ in the design of the central-injection unit. All systems feature an injector located above the throttle plate; they differ from multipoint injection units in that they frequently operate at low pressure (0.7...1 bar). This means that an inexpensive, hydrodynamic electric fuel pump can be used; this is generally installed in the fuel tank. The injector is flushed continuously by the fuel which surrounds it in order to inhibit the formation of air bubbles. This arrangement is an absolute necessity in a low-pressure system. The designation 'Single-Point Injection (SPI)' corresponds to the terms Central Fuel Injection (CFI), Throttle Body Injection (TBI) and Mono-Jetronic (Bosch).

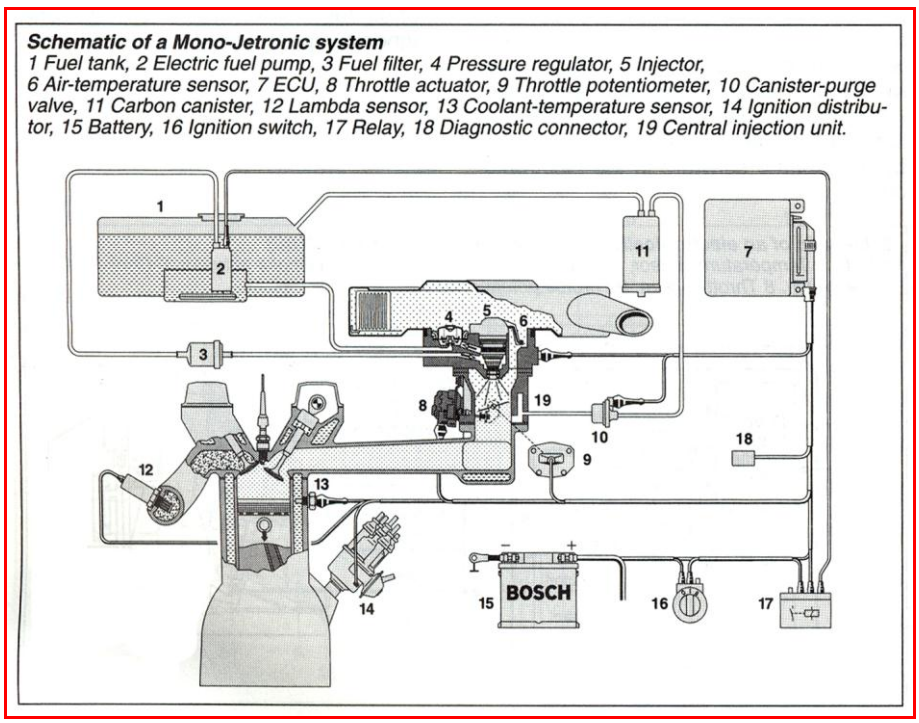

Figure 1.44: Schematic of a Mono-Jetronic system

Multipoint

Types of Multipoint Fuel-Injection Systems

- K-Jetronic
- KE-Jetronic
- L-Jetronic
- LH-Jetronic

Components of Multipoint Fuel-Injection Systems

Electric Fuel Pump

The electric fuel pump must deliver sufficient quantities of fuel to the engine while maintaining enough pressure for efficient injection under all operating conditions. Essential requirements include:

- Maintaining flow rates between 60 and 200 liters/h at the rated voltage supply,
- Maintaining fuel-system pressures of 300 400kpa
- The ability to pressurize the system during operation at 50.60% of the rated voltage, important for cold-starting response.

Airflow Sensor

The airflow sensor consists of an air funnel and a pivoting airflow sensor plate. A counterweight compensates for the weight of the sensor plate and pivot assembly. The sensor plate is displaced by the air flow, while the control plunger in the fuel distributor exerts hydraulic counter pressure to maintain the system in a balanced state. The position of the air-flow sensor plate provides an index of intake air flow, and is transmitted to the fuel distributor's control plunger by a lever.

Warm-up Regulator

The warm-up regulator is controlled by an electrically-heated bimetallic element; it enriches the mixture in the warm-up phase by reducing the counter pressure exerted against the control plunger. A reduction in the control pressure means that the stroke of the airflow sensor plate for a given airflow increases (reflecting the larger metering-slot aperture). The result is a richer mixture during warm-up. Where desired, the warm-up regulator can be expanded to incorporate the following functions:

- Full-throttle enrichment,
- Acceleration enrichment,
- Altitude compensation.

Auxiliary-air Valve

The auxiliary-air valve, controlled by either a bimetallic spring or an expansion element, supplies the engine with additional air (which is monitored by the airflow sensor, but bypasses the throttle valve) during the warm-up phase. This supplementary air compensates for the cold engine's higher friction losses; it either maintains the normal idle speed or increases it in order to heat the engine and exhaust more quickly.

Lambda Mixture Control

Open-loop control systems do not regulate the air/fuel ratio with enough accuracy to allow compliance with stringent emissions limits.

When lambda closed-loop control (required for operation of the 3-way catalytic converter) is installed, all of injection system must include an electronic control unit which uses the Lambda sensor's signal as its main input variable.

A solenoid frequency valve regulates the mixture ratio by controlling the pressure differential at the metering slits. However, this principle cannot be applied to meet the more stringent emissions requirements scheduled for the future.

Electro-hydraulic Pressure Actuator

This electro-hydraulic actuator is flange-mounted on the fuel distributor. It is an electrically-controlled pressure regulator which operates using the nozzle/flapper-plate system. The mixture enrichment is directly proportional to the current flow.

Electronic Control Unit (ECU)

The ECU processes signals from the ignition (engine speed), temperature sensor (coolant temperature), throttle potentiometer (intake airflow), throttle switch (idle and overrun, WOT), starter switch, Lambda sensor, pressure sensor and other sensors. Its most important functions are the control of:

- Starting and post-start enrichment
- Warm-up enrichment
- Acceleration enrichment
- Full-throttle enrichment
- Overrun fuel cutoff
- Engine-speed limitation
- Idle-speed control
- Altitude compensation
- Closed-loop lambda control.

A coding switch (trim plug) makes it possible to select between operation with lambda control (with catalytic converter) and without it. This permits a choice between leaded and unleaded gasoline.

Injectors

The injectors meter and atomize the fuel. When the solenoid coil is energized, the injector needle is lifted a mere 0.05 mm from its seat.

Throttle switch

This transmits a control signal to the ECU when the throttle valve is either completely closed (idle) or fully opened (full-throttle).

Engine-temperature sensor

The engine-temperature sensor is designed as a temperature-sensitive resistor (thermistor) and controls the warm-up enrichment.

Lambda closed-loop control

The ECU compares the signal from the Lambda sensor with a set point value before activating a two-state controller. The control adjustment is then performed, as are all corrections, by modifying the injection duration.

Combined Ignition and Fuel-Injection System (Motronic)

Motronic consists of a number of subsystems. When ignition and fuel injection are integrated within a single system, the individual elements acquire flexibility and operational scope well beyond that available from each system working separately. Motronic features numerous three-dimensional performance maps; there are no intrinsic programming

restrictions and the maps can be applied for a multiplicity of functions. The basic Motronic system includes additional sub-functions for emissions control and fuel economy.

Adaptive input control is now a standard feature of the lambda control system; it is particularly important for maintaining stable exhaust emissions throughout the vehicle's service life.

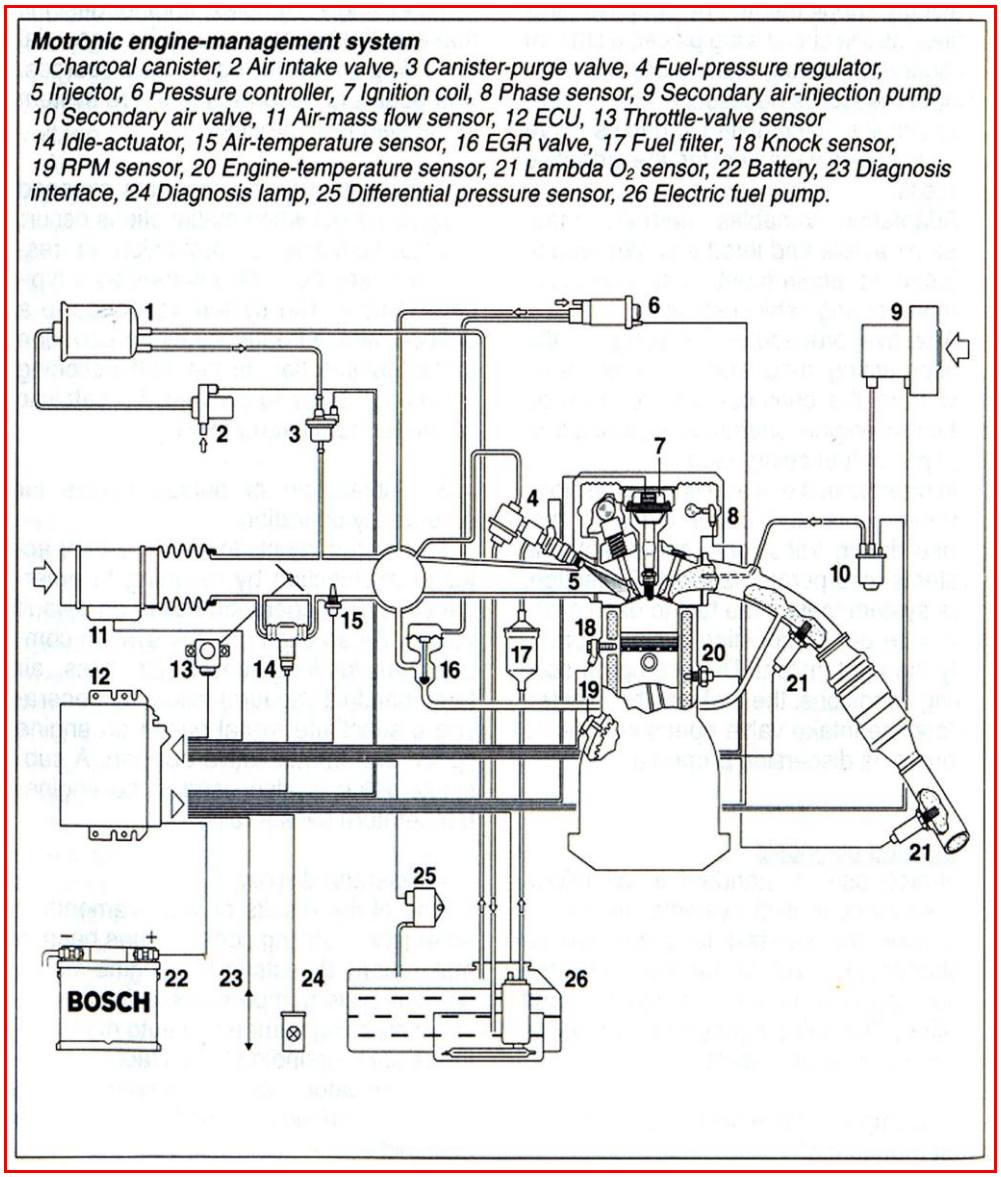

Figure 1.45: Motronic System

APPLICATION ACTIVITY

Use technical English about the automotive engine technology.

Steps of process	Suggestions
➢ Find a text about this process and translate. ➢ Translate the text given below	➢ Please read all of the text. ➢ If you do not know words in text, research the meaning during translation ➢ Use English dictionary for the meaning of words from English to Turkish ➢ You can find detailed information about the technical words in the text. ➢ Make research about automotive engine technology

When the piston reaches the bottom of its stroke, the intake valve closes and the crankshaft forces the piston back up through the cylinder. This compresses the air-fuel mixture in the combustion chamber.

As the piston nears the top of the compression stroke, the air-fuel mixture is ignited by a spark from the spark plug. This explodes the mixture, and the pressure of the rapidly expanding gas drives the piston down through the cylinder. Both valves are closed during this firing stroke.

After reaching the bottom of the firing stroke, the exhaust valve opens, and the spinning crankshaft forces the piston up through the cylinder once again. This time all the burned gases are driven, or exhausted, from the cylinder and combustion chamber.

When the piston reaches the top of the exhaust stroke, the exhaust valve closes and the intake opens. The piston is drawn down on another intake stroke.

CHECKLIST

If you have behaviors listed below, evaluate yourself putting (X) in “Yes” box for your earned skills within the scope of this activity otherwise put (X) in “No” box.

Evaluation Criteria	Yes	No
1. Have you ever had the knowledge of technical English about the terms of car technology?		
2. Have you ever had the knowledge of technical English about the classification of car engines?		
3. Have you ever had the knowledge of technical English about the main parts of car engine?		
4. Have you ever had the knowledge of technical English about the running principles of car engines?		
5. Have you ever had the knowledge of technical English about systems of the car engines?		
6. Did you make research on the subject?		

EVALUATION

Please review your "No" answers in the form at the end of the evaluation. If you do not find yourself enough, repeat learning activity. If you give all your answers "Yes" to all questions, pass to the "Measuring and Evaluation".

MEASURING AND EVALUATION

Read the sentences and answer the questions. Then, compare your answers with the answer key at the end of the module.

1. Which one reaches the crown of the piston at the top of the cylinder?
- **A)** Top Dead Center (T.D.C.)
- **B)** Bottom Dead Center (B.D.C.)
- **C)** Stroke
- **D)** Combustion Chamber

2. Which one is not a stationary part of the engine?
- **A)** Cylinder block
- **B)** Cylinder head
- **C)** Oil pan
- **D)** Connecting rod

3. Which engine does not contain block?
- **A)** Liners
- **B)** Water passage
- **C)** Cooling water
- **D)** Mixture passage

4. Which one is the distance where the piston moves in the cylinder?
- **A)** Bore
- **B)** Cylinder
- **C)** Stroke
- **D)** Stroke volume

5. Which one is type of engine which the cylinders are mounted in a vertical bank above the crankshaft like form the letter?
- **A)** In-line engine
- **B)** T type engine
- **C)** V-Formation engine
- **D)** Horizontally opposed engine

6. Which one is the function of the lubrication oil?
- **A)** To reduce noise
- **B)** To improve efficiency
- **C)** To prevent rust
- **D)** All

7. Which one is not the moving part of the engine?
- **A)** Piston
- **B)** Connecting rod
- **C)** Crankshaft
- **D)** Cylinder

8. Which one is the position that two valves are closed and that the piston is at T.D.C. during the end of the compression stroke just before the start of the power stroke?

A) Overlap of the valves
B) The end of the compression stroke
C) Exhaust stroke
D) Intake stroke

9. Which one is the product stroke volume and the cylinder numbers of an engine?

A) Total volume
B) Cylinder volume
C) Combustion chamber volume
D) Stroke volume

10. Which one provides to connect a piston to a crankpin on the crankshaft?

A) Bearing
B) Connecting rod
C) Ring
D) Piston pim

11. Which one converts the reciprocating motion (up and down) to the rotary motion?

A) Piston rings
B) Connecting rod
C) Crankshaft
D) Flywheel

12. Where does the crown of the piston at the bottom of the cylinder reach?

A) Top Dead Center (T.D.C.)
B) Bottom Dead Center (B.D.C.)
C) Stroke
D) Combustion Chamber

13. Which one is the volume that is between the crown of piston and cylinder head while the piston is at T.D.C.?

A) Total volume
B) Cylinder volume
C) Combustion chamber volume
D) Stroke volume

14. Which one is the total stroke volume and the combustion chamber volume?

A) Total volume
B) Cylinder volume
C) Combustion chamber volume
D) Stroke volume

15. Which one is the type of engine which the cylinders are usually formed in a vertical bank above the crankshaft?

A) In-line engine
B) I type engine
C) V-Formation engine
D) Horizontally opposed engine

16. Which one provides a seal between the cylinder block and cylinder head?

A) Valve guide
B) Head gasket
C) Valve seat
D) None

17. Which one plays the role of gathering exhaust gases from cylinders?

A) Intake manifold
B) Valve
C) Exhaust manifold
D) Cylinder head

18. Which one is sealed of the high-pressure burned gases from the combustion chamber go into the crankcase?

A) Piston
B) Cylinder
C) Valve
D) Piston rings

19. Which one provides the opening and closing of the valves?

A) Crankshaft
B) Flywheel
C) Valve mechanism
D) None

20. Which one absorbs energy that the engine produces during the power stroke?

A) Crankshaft
B) Hydraulic lifters
C) Fuel pump
D) Flywheel

EVALUATION

Please compare the answers with the answer key. If you have wrong answers, you need to review the Learning Activity. If you give right answers to all questions, pass to the next learning activity

LEARNING ACTIVITY-2

AIM

You will use the technical English about automotive power transfer parts.

SEARCH

- Research the basic definitions and terms with the relevant automotive power transfer parts using automotive services in your surroundings and at your school workshops and what happening with the equivalents of technical English. Bring into a report the results of making research. Make a presentation to your teacher and your friends in your classroom.

2. AUTOMOTIVE POWER TRANSFER PARTS

2.1. Clutches

Mechanism to engage or disengage engine from the remaining part of driveline connects engine to driveline when power is needed and allows engine to operate when power is not needed.

The most common used clutches are:

2.1.1. Types of Clutches

2.1.1.1. Single Disc Type (Dry)

Composed of two units:

- A driving unit integral with the crankshaft.
- A driven unit integral with the transmission elements.

The disc consists of:

- Two crowns with good friction coefficient and good resistance to high temperature, riveted to thin plate, cut into sectors in order to avoid buckling when heated.
- A hub, grooved inside, which allows the rotation of the gear box input shaft and slides on it.

2.1.1.2. Diaphragm Clutch

The traditional helical springs that operate the pressure plate of the clutch are replaced by a "cup" spring (or diaphragm spring) made of a thin steel disc which has been given a conical profile. This disc gives the required pressure over the clutch driven plate when it is pushed back by the thrust collar.

Advantages:

- Smoother pedal effort
- Good resistance to centrifugal force
- Better cooling
- Simplified maintenance

2.1.2. What Does The Clutch Do?

The clutch connects the engine to a manual transmission. Stepping on a foot pedal disengages the clutch so that the engine can run without turning the wheels. This allows the driver to shift the transmission from one gear to another. A friction material on both sides of the clutch disc, similar to that in brake linings, allows the disc to be engaged gradually for smooth starts when the engine is operating at over 1.000 rpm.

The clutch assembly consists of three parts:

- The engine flywheel
- The clutch disc
- The pressure plate

The pressure plate is bolted to the flywheel and turns with it. The clutch disc is a flat steel disc with a splined hub that slides on the transmission input shaft.

Strong springs squeeze the clutch disc between the flywheel and pressure plate. When the clutch disc is locked in place, engine power passes from flywheel to clutch disc to transmission input shaft, thereby driving the car. Depressing the clutch pedal moves the pressure plate back and frees the disc from the flywheel. The disc slides on its splines so that it touches neither the flywheel nor the pressure plate.

Clutches are named after the kind of pressure springs they employ. Coil-spring clutches, once common, are giving way to diaphragm clutches because the latter are lighter, cheaper and reduce pedal pressure. Some coil-spring clutches have centrifugal weights that increase the clamping force of the springs as engine speed increases. They are called centrifugal clutches.

2.1.3. How Does A Clutch Work?

2.1.3.1. Coil-Spring Clutch in Operation

Engaged:

Coil springs clamp the clutch disc tightly between the pressure plate and the flywheel. Thus, the flywheel and pressure plate turn the clutch disc at full engine speed. The disc is

splined to the input shaft of the transmission; so the engine is firmly linked to the transmission. Only one coil spring and finger are shown, for clarity.

Disengaged:

The throw-out bearing presses on the release fingers, which pull the pressure plate way from the flywheel and compress the coil springs. This frees the disc, which slides on its splines so that it touches neither the flywheel nor the pressure plate. Thus the engine turns freely with no connection to the transmission.

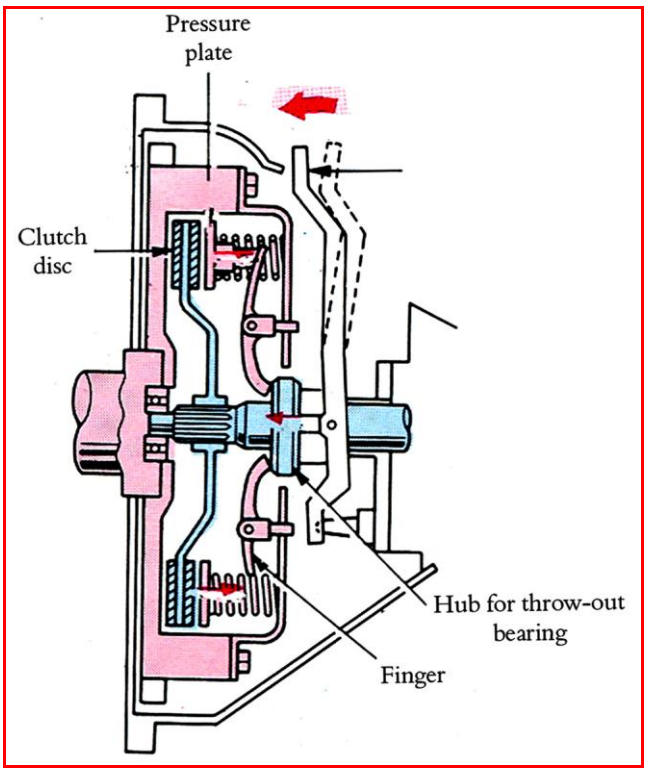

Figure 2.1: Description of the coil-spring clutch

2.1.3.2. Diaphragm Clutch

Diaphragm Clutch in Operation
Diaphragm spring:

A conical plate of spring steel can do the same job as coil springs. The plate can be flexed, like the bottom of oil can, so that it is concave or flat. When the driver steps on the clutch pedal, the throw-out bearing puts pressure against the center of the steel plate, pushing it against its fulcrum and flexing it.

Engaged:

Flat diaphragm spring exerts even pressure around its outer edge, forcing the pressure plate to clamp the clutch disc to the flywheel. With the clutch disc clamped to the flywheel, the engine drives the transmission input shaft and eventually, the car's wheels.

Disengaged:

When the operating fork presses the throw-out bearing against the center of the conical diaphragm spring, it pops inward, releasing the pressure plate from the flywhee1 and freeing the clutch disc so that the engine can turn without driving the transmission.

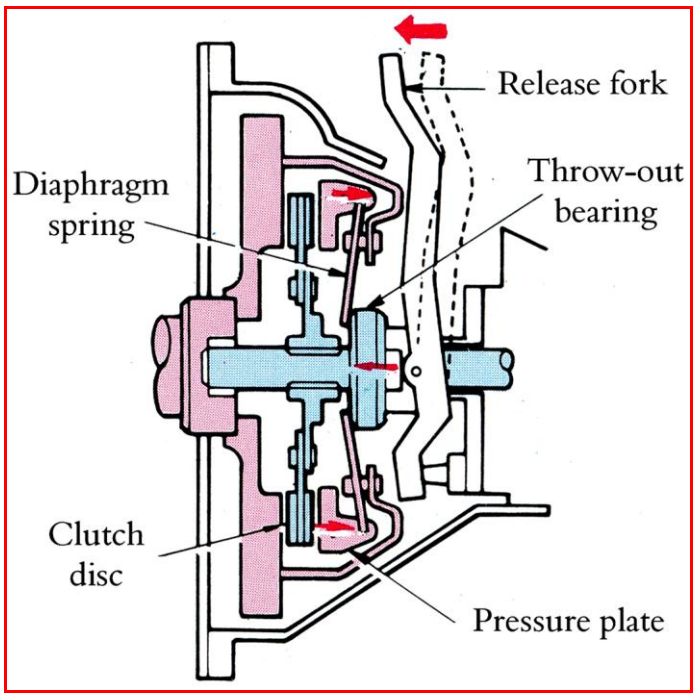

Figure 2.2: Description of the spring clutch

2.1.4. How Does The Pedal Run The Clutch?

2.1.4.1. Mechanical Linkage

On many large North American cars, the motion of the driver's foot on the clutch pedal is transferred to the throw-out bearing by a system of roads and levels.

2.1.4.2. Hydraulic Operation

Pushing hydraulic fluid through a pipe from a master cylinder to a slave cylinder provides friction-free thrust to the clutch-operating fork on many imported cars.

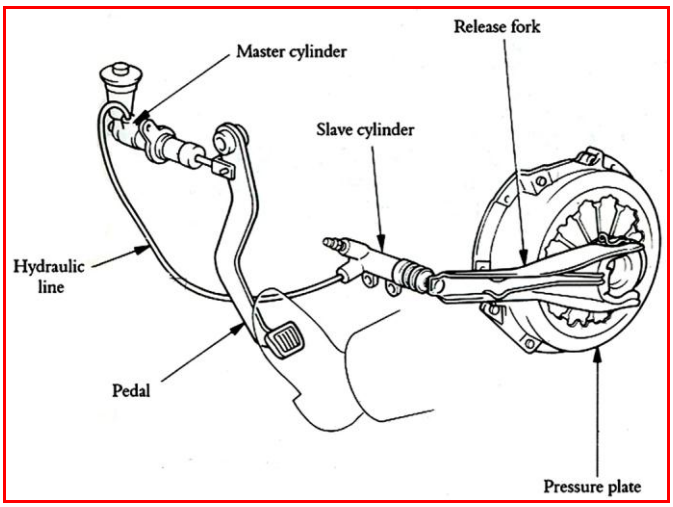

Figure 2.3: Hydraulic operation

2.1.4.3. Cable operation

The clutch on many small cars is operated by pulling a cable instead of pushing a rod. The cable slides inside a sheath so that it works smoothly around corners.

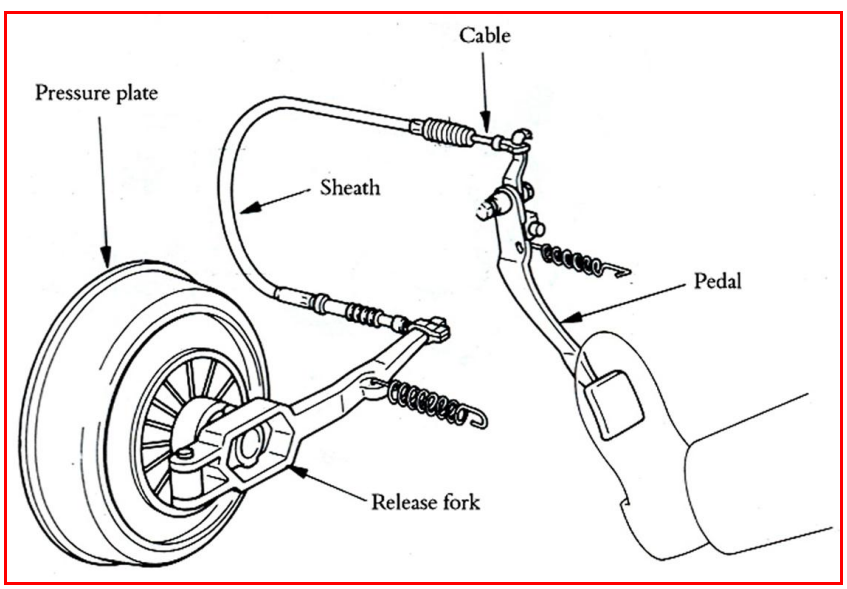

Figure 2.4: Cable operation

2.2. The Gearbox

2.2.1. How Does The Engine Turn The Wheels?

The drive train transmits power from the engine to the wheels that move the car. In a conventional auto, with its engine in front and drive wheels in the rear, the engine turns shafts in the transmission, which transmits power through a drive shaft to the rear axle. When a car turns, differential gears inside the axle housing permit the outside wheel to make more revolutions than the inside wheel, which has a shorter distance to travel. Universal joints (U-joints) in the drive shaft allow the rear axle to move up and down.

In a front-wheel-drive car or a rear-engine car, there is no drive shaft. The engine drives a combined transmission and differential called a transaxle, which turns the two axle shafts that drive the wheels. U-joints in these axle shafts let the suspension move up and down and allow the front wheels to steer a front-wheel-drive car.

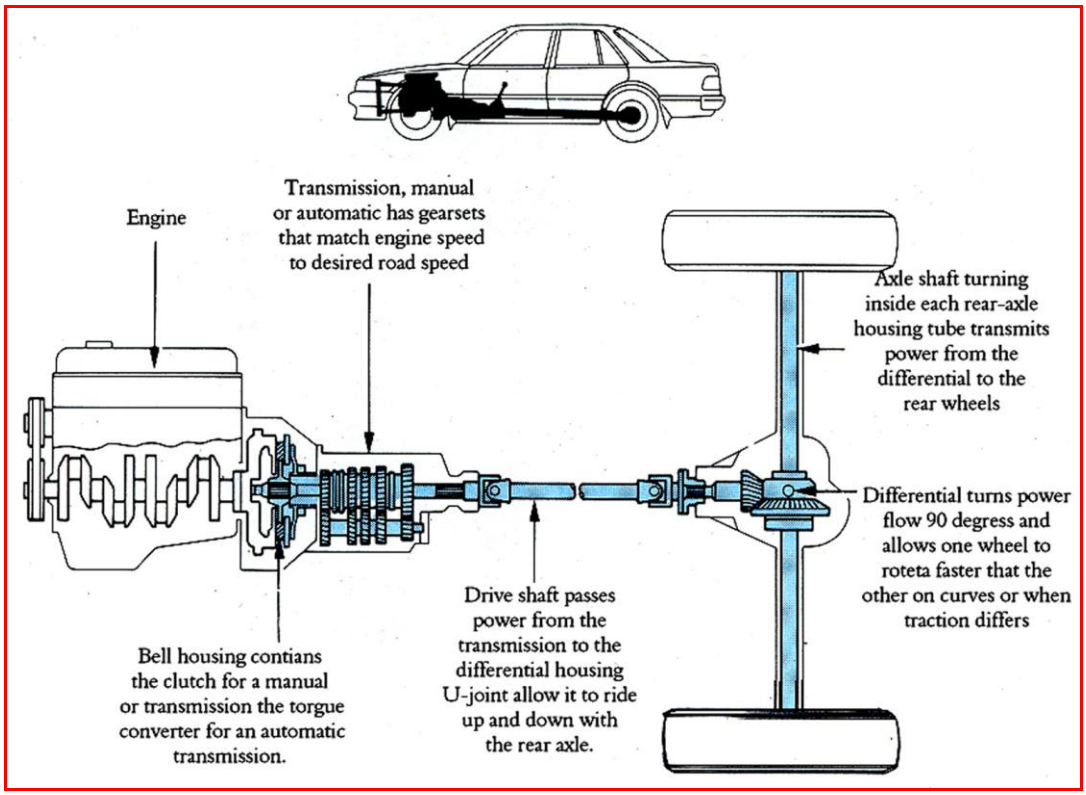

Figure 2.5: Power Transfer Parts of Front-wheel Drive

A car engine develops useful power at relatively high revolutions per minute (rpm). A typical engine produces its motive power between 1.500 and 3.500 to 5.000 rpm. If the wheels turn once for every crank shaft revolution, the car can travel only between 50 and 270 mph (80 and 435 km/h). Thus, engine speed must be geared down for road use.

Differential gears allow the drive shaft to run two to four times faster than the wheels. Additional gears in the transmission further reduce the speed of the drive wheels while allowing the engine to run in its useful power range. The faster the engine turns in relation to the wheels, the more torque (twisting power) it develops; so the transmission acts as a torque multiplier. Maximum torque is developed in the transmission's lowest gears (First and second) but they lower the car's speed. Three to five forward gears match engine speeds to driving requirements at any given moment. The gears may be shifted manually or automatically, depending on the type of transmission in the car.

2.2.1.1. Manual Transmission

Manual transmission allows the driver to change the ratio between engine speed and road speed. Moving the shift lever slides a collar that engages a set of gears. Most manual transmissions have three, four or five forward speeds plus Neutral and Reverse. Neutral disengages all drive gears so that the engine can idle while the clutch is engaged and the car is stationary.

2.2.1.2. Automatic Transmission

Automatic transmission uses a hydraulic system to shift the gears and transmit power automatically. It shifts into higher gears as the car's speed increases and shifts into lower gears for climbing hills or passing. Simply pushing down on the accelerator pedal controls the speed of the car. The advantage is easier driving but with most automatics there is a loss in fuel economy.

2.2.1.3. U-Joint

Universal joints hinge in two planes, like a human wrist. The rear suspension must move up and down on its springs when the car travels over bumps. Universal joints, sometimes called U-joints, allow the drive shaft to flex when the axle is moving. Cars with rear engines must have U-joints in the axle shafts. Cars with front-wheel drive use special U-joints called constant velocity joints.

2.2.2. What Does The Transmission Do?

The transmission makes it possible to match the engine's power-producing speeds to the speed of the drive wheels. An engine produces little torque, or twisting power, at low engine rpm. A transmission's lower gears allow the engine to turn very fast in comparison to the drive wheels, thereby providing maximum torque in order to start the car from rest. High gear keeps engine rpm low for maximum fuel economy at cruising speeds. When the car encounters a hill, the engine will falter and stall unless an intermediate gear is selected. The gears between First and High bridge the gap between the torque required to start a fully loaded car from rest and that required to keep a car rolling along at highway speeds. In the days when engines were big and produced lots of torque, only three forward speeds were needed. Today's smaller engines produce less torque at higher rpm and often require four or five gears.

The clutch disc slides on splines cut into the transmission input shaft, turning the shaft I whenever the clutch is engaged and the engine is running. Splines are matching parallel grooves in a hub and shaft that allow the hub to slide back and forth on the shaft but force the two parts to turn as one.

A lever enables a small force moving over a great distance to lift a large weight a lesser distance (top). Gears are toothed wheels that act like a series of levers (bottom). Torque transmitted through a small gear turns a larger gear a lesser amount, multiplying the torque but reducing the original speed.

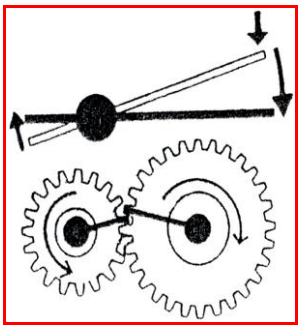

Figure 2.6: A lever gear

A spur gear has straight teeth cut parallel to its axis of rotation. Spur gears tend to be noisy in operation, but they are cheaper to machine and require slightly less power to turn than helical gears do. Spur gears are used only for Reverse on modern transmissions.

A helical gear has curved teeth cut at an angle to the axis of rotation. The curve forms a spiral (called a helix) similar to a screw thread. The overlap between adjoining teeth is greater in helical gears than in spur gears, so that power is transferred more smoothly and quietly.

2.2.3. How Does A Manual Transmission Work?

A manual transmission allows the driver to select the gears he needs to cope with varying road conditions. To shift gears, a driver must depress the clutch pedal to disconnect the engine from the transmission then move the shift lever. The lever moves collars inside the transmission to engage various sets of gears.

Gear ratios are determined by the number of teeth on the driven gear compared to the driving gear. If the driven gear has 20 teeth and the driving gear has 10, the gear ratio is 2:1. The driven gear will rotate at half the speed of the driving gear, but it will pass on twice the torque. The lowest gear in the transmission must multiply engine torque enough to start a fully loaded car moving up a steep hill. On a small car with a four-speed transmission, First gear might have a ratio of 3.5:1. Other typical ratios would be 2:1 in Second, 1.5:1 in Third, and 1:1 in Fourth. If the rear-axle ratio is 3:1, the overall ratios between crankshaft speed and wheel speed are found by multiplying the two ratios 10.5:1 in First, 6:1 in Second, 4.5:1 in Third and 3:1 in Fourth.

A car with a bigger engine would not need so much torque multiplication and might use a three-speed transmission with ratios of 2.8:1, 1.5:1, and 1:1, and a rear-axle ratio of 2.75:1.

2.2.3.1. Neutral

All the gear sets except those needed for reverse are constantly in mesh, the tan gears are fixed to their shafts; those shown in gray revolve on freewheeling hubs, In Neutral all the gears on the output shaft are allowed to freewheel, and no power is transmitted.

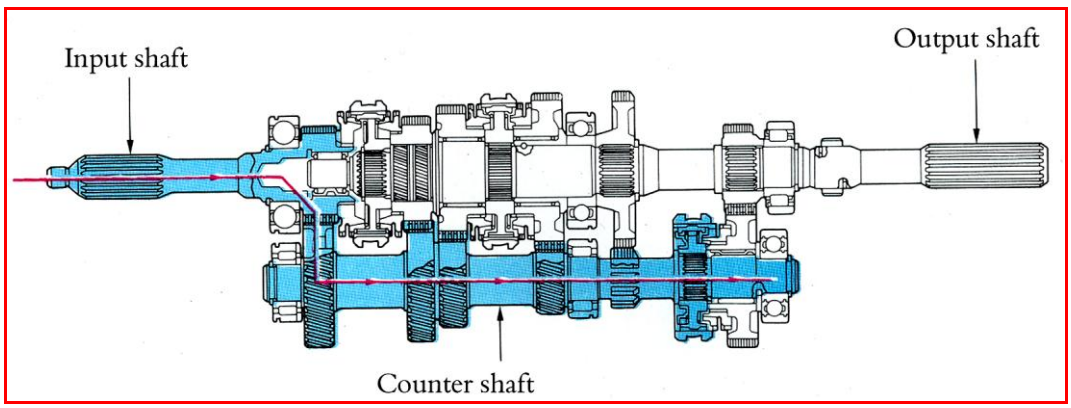

Figure 2.7: Neutral position

2.2.3.2. First Gear

When first gear is engaged, a collar splined to the output shaft slides into contact with the largest gear and locks it to the shaft so that the power is transmitted. The output shaft may rotate once for every three revolutions of the input shaft, providing maximum torque.

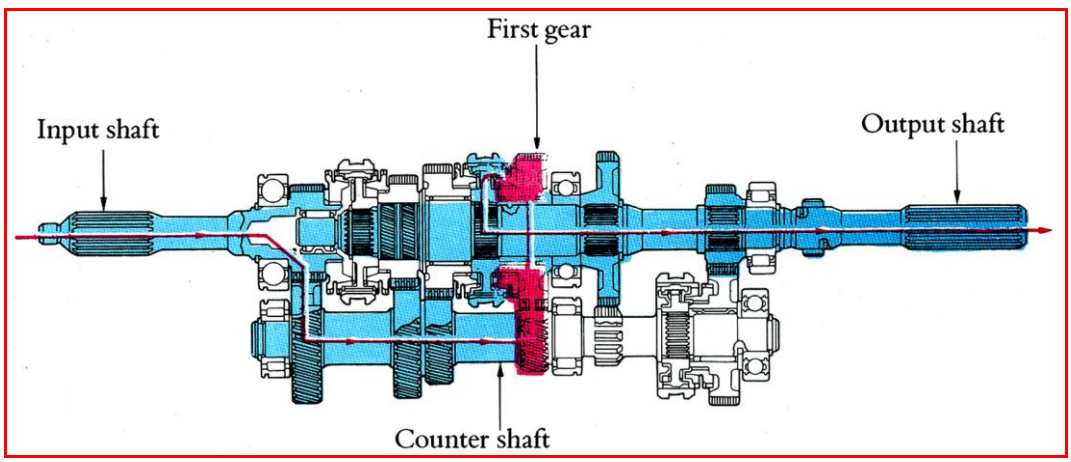

Figure 2.8: First gear position

2.2.3.3. Second Gear

When the transmission is shifted into Second, a selector fork (not shown here) slides the collar forward, out of contact with First gear, to engage and drive the second-largest output gear. This gear provides enough torque for brisk acceleration or for climbing steep hills.

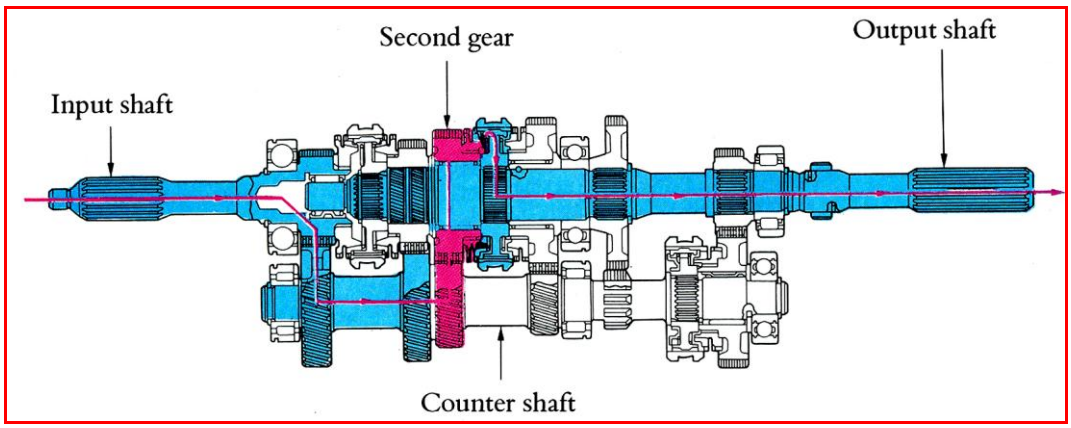

Figure 29: Second gear position

2.2.3.4. Third Gear

To shift into Third, the rear collar is disengaged from First and second gears, and the forward collar slides into engagement with the smallest gear. With its ratio of about 1.5:1, Third gear provides enough torque or high-speed passing or for climbing moderately steep hills.

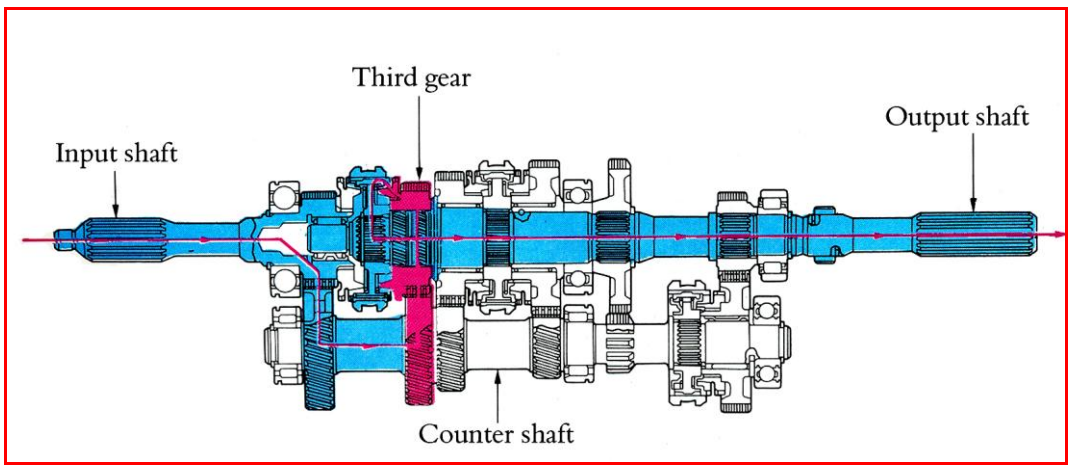

Figure 2.10: Third gear position

2.2.3.5. Fourth Gear

In High gear, called direct drive by engineers, the forward collar slides up to bridge the gap between the splined input and output shafts so that they rotate as one. The ratio of this "gear" is obviously 1: 1. The other gear sets continue to freewheel and do not transmit power.

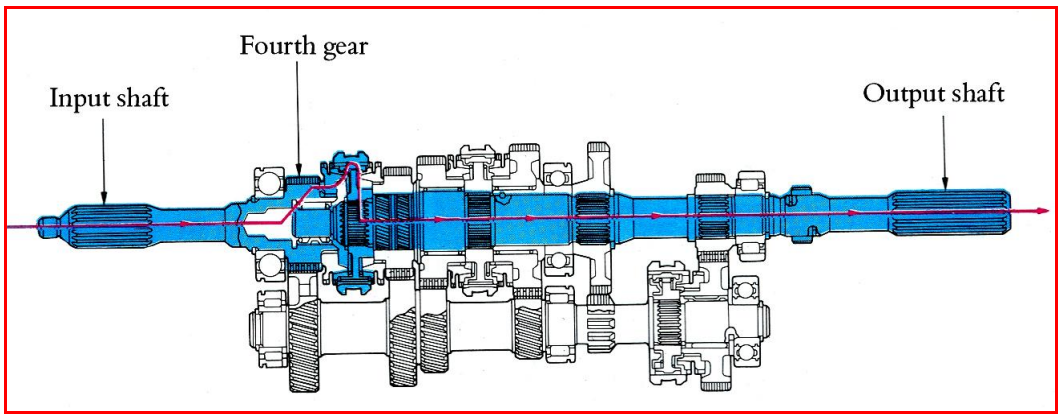

Figure 2.11: Fourth gear position

2.2.3.6. Reverse

When Reverse is selected, both collars are disengaged and the idler gear is engaged with spur gears on the countershaft and output shaft. This extra gear reverses the output shaft's direction of rotation, causing the car to back up when the clutch is engaged.

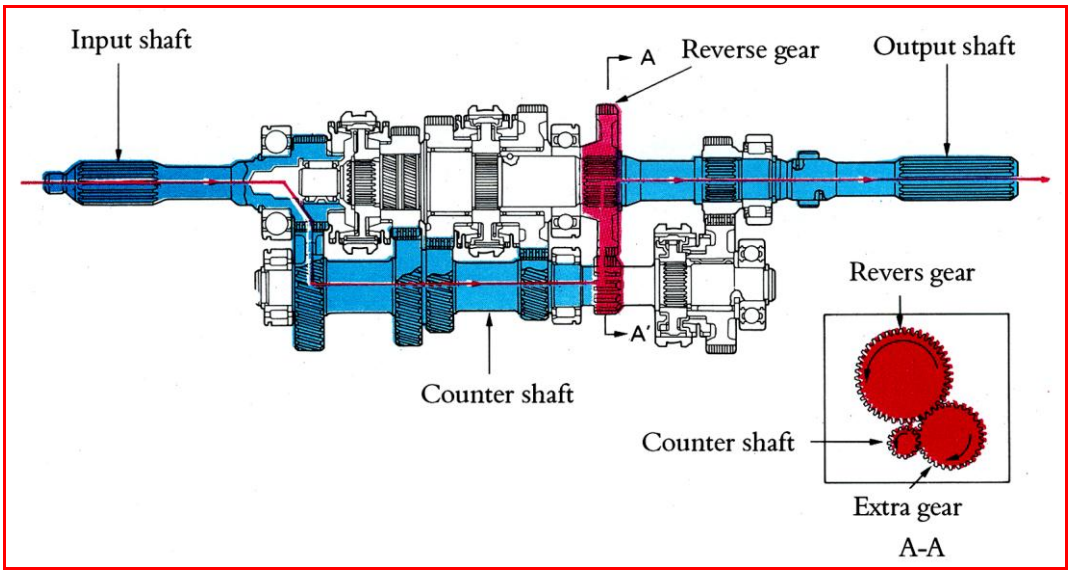

Figure 2.12: Reverse gear position

2.2.4. How the Shift Lever Changes Gears

Linkage from a shift lever, mounted on the floor or steering column, moves the forks inside a manual transmission to engage the gears. The shift forks fit into grooves machined into the circumference of the shift collars. Each two-faced collar locks one gear to the output shaft when moved forward, and locks another gear when it is moved back. That is why First-Second and Third-Fourth have their own slots in the H-shaped shift pattern.

The only gear that actually shifts is Reverse. The others are engaged when the shifting fork forces the collar against an already meshed gear, locking it to the rotating output shaft.

Each shifting fork is attached to a rod in a directly shifted transmission or to a lever and rod in a transmission with side linkage. When the driver moves the shift lever, it pivots on a ball-in-socket joint and moves a control rod in the opposite direction. A collar grips a gear and when the clutch pedal is released, power is transmitted through the transmission to the wheels.

2.2.5. Synchromesh

Large teeth on the side of each gear engage similar teeth on the shift collars in order to lock a gear to the output shaft. These teeth are called dogs. Originally, these dogs were simply forced together by the shift fork until they finally meshed with a great crunch. To do the job more quietly and smoothly a synchronizing system has been devised that allows the two sets of dogs to reach the same speed before they are engaged.

As the collar is pushed toward a gear a conical ring on the gear comes into contact with a matching conical hole in the collar. The friction between the two conical surfaces brings the speed of the free-wheeling gear up or down to match the speed of the output shaft and collar. Once their speeds are synchronized, the two sets of dog can mesh smoothly. A system of blocking rings and spring-loaded sleeves prevent the dogs from being forced into contact until they are rotating at about the same speed.

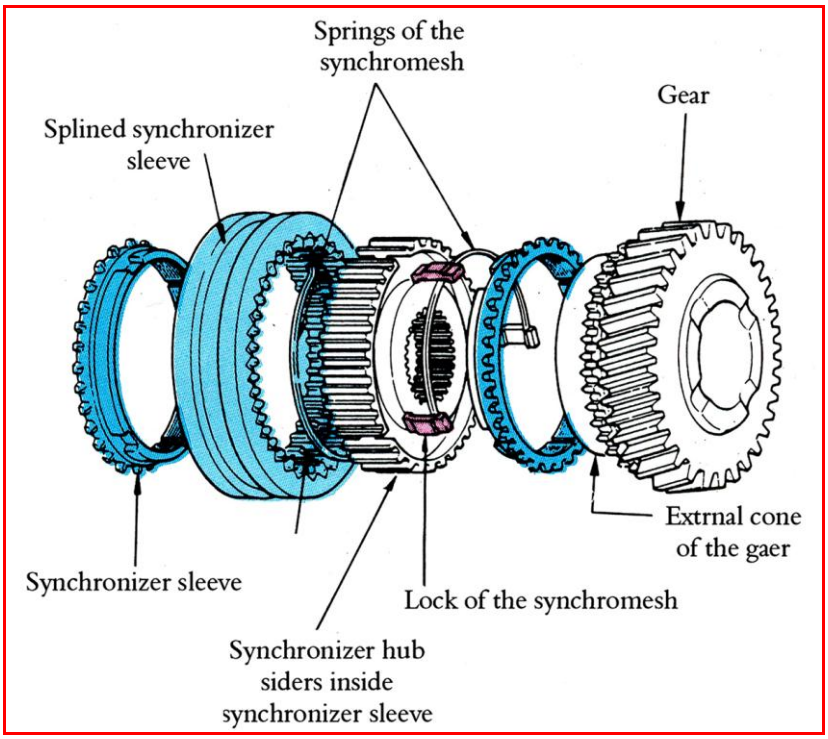

Figure 2.13: Description of the synchromesh system

2.2.6. Automatic Transmission Passes Power Through A Fluid

An automatic transmission is made possible by a fluid coupling that is placed between the transmission and the engine. There are two parts in a fluid coupling: the impeller, which is driven by the engine, and the turbine, which turns the transmission input shaft. Both are bowl shaped and have a number of partitions, called vanes. The two bowls face each other, separated by a small clearance, in a housing filled with oil.

The oil sloshing inside the coupling allows the engine to idle at low speeds. At engine speeds above 1,000 rpm, the impeller imparts so many swirls to the fluid that the turbine also revolves and the car begins to move if it is in gear and the brakes are released. Above 2,000 rpm the turbine turns at about 98 percent of the speed of the impeller; this 2 percent rpm loss is called slip.

2.2.6.1. Progressive engagement of a fluid clutch:

The impeller is attached to the engine crankshaft. It faces the turbine in an oil bath at low rpm (left) the oil transmits too little torque from the impeller to the turbine to move the car, so that the engine idles while the car remains stationary. As engine speed increases centrifugal force throws more oil from the impeller into the turbine, transmitting some torque (center), but there is still so much slip that the turbine turns the output shaft much more slowly than the engine turns the input shaft. The car begins to move. Once the engine

reaches a pre-set speed, usually 1.500 to 2,000 rpm, the circulating oil transmits maximum power (right). Slippage between impeller and turbine rpm drops to as little as 2 percent and the car accelerates to the speed dictated by the position of the accelerator pedal. Some newer cars are equipped with lockup converters which eliminate all slippage at highway speeds for increased fuel economy. When the car reaches a pre-set speed, a clutch locks the impeller and turbine together so that they rotate as one.

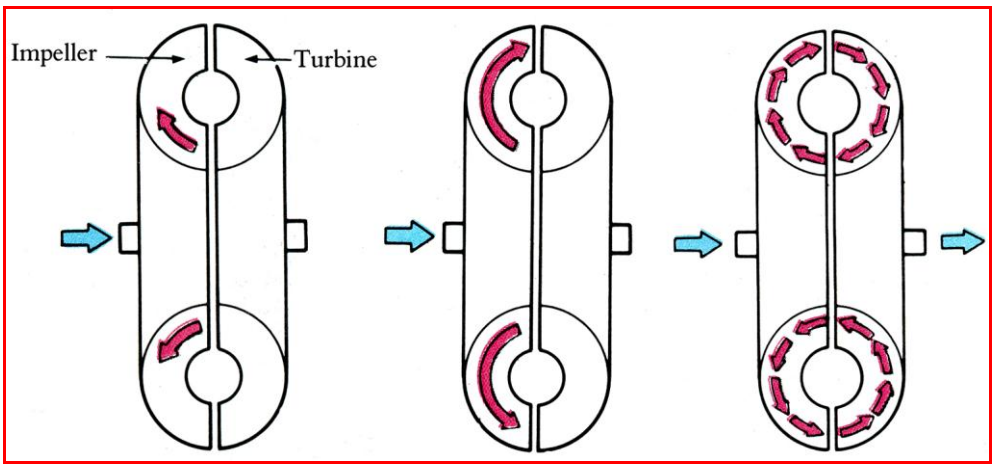

Figure 2.14: Progressive engagement of fluid clutch

2.2.6.2. The Torque Converter

The engine torque, or twisting force, applied to the turbine in a fluid coupling can never quite equal the torque delivered by the impeller to the transmission because there is always some slip. This slip accounts for the loss in fuel economy that occurs with automatic transmissions.

At low engine speeds the oil bounces from the turbine vanes back toward the impeller and circulates in a counter-clockwise direction. This is opposite to the clockwise flow that the impeller imparts to the oil and some engine torque is absorbed in reversing the flow. Modern automatic transmissions use a torque converter to overcome this torque loss. A torque converter is a fluid coupling with a third member, called a stator, mounted between the turbine and the impeller. A one-way clutch allows the stator to rotate clockwise but locks it in place when it begins to turn counterclockwise.

At low speeds, the counterclockwise flow of oil locks the stator so it cannot turn. The stator vanes divert the oil flowing past them so that it is again circulating in a clockwise direction when it hits the impeller vanes. This has the effect of doubling the torque that the impeller delivers to the turbine.

As engine speed increases, the oil stops bouncing off the turbine vanes and begins circulating in a clockwise direction the stator begins to turn on its one-way clutch until it is freewheeling at about the same speed as the turbine and impeller. The stator's multiplication of torque gradually drops from 2.3:1 at startup to zero at cruising speeds.

A modern automatic transmission consists of a torque converter coupled to a two, three or four speed gearbox. The latest development in automatic transmissions is the lockup converter. At cruising speeds, the turbine and impeller are locked together by a clutch to eliminate the slip and lost fuel economy of conventional automatics.

2.2.6.3. Changing gears without a clutch

The engine needs more torque multiplication than the torque converter alone can supply, in order to start a car up from rest, to climb hills and to accelerate for passing. This extra torque is provided by planetary gears mounted behind the torque converter. Two sets of planetary gears can provide three forward speeds plus reverse and this is the usual arrangement in an automatic transmission, although some automatics are built with two or four forward speeds.

Planetary gears can be shifted without disconnecting the engine from the transmission. A planetary gear set consists of a sun gear, a ring gear with internal teeth, and several planet gears that rotate between the sun and ring gears, turning a yoke-like planet carrier. In a three-speed automatic transmission, the two planetary gear sets have sun gears that are permanently connected. By using hydraulically operated clutches or brake bands to lock or release parts of the two gear sets, varying ratios can be provided. The illustrations (at right and below) show how planetary gears work and how they are arranged in the transmission.

2.2.6.4. How Two Planetary Gear Sets Change Ratios

First gear

Forward-drive clutch is engaged so that engine drive (dark line) turns the first ring gear. This causes the first planet gears to drive the common sun gear in the opposite direction The second planet carrier is held by its brake band (arrows), causing its planets to drive the second ring gear and output shaft in the opposite direction. This produces two reversals of direction and two reductions in engine speed.

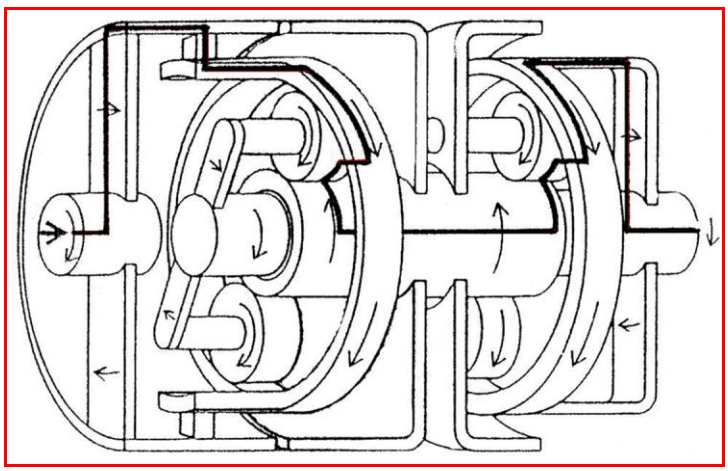

Figure 2.15: First gear

Second gear

When the forward-drive clutch is engaged, the engine drives the firs ring gear. The common sun gear is braked (arrows), so that the first ring gear drives the planet gears around it and they drive their carrier in the same direction. The carrier shaft is also the output shaft, giving just one speed reduction. The second planet gears and carrier (dark parts) freewheel.

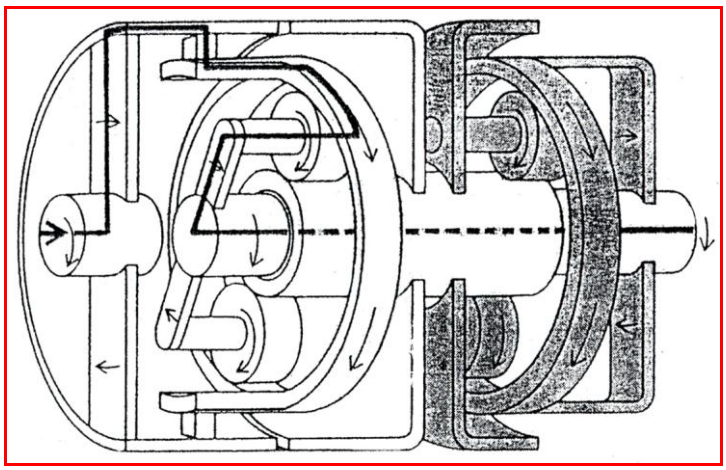

Figure 2.16: Second gear

High gear

Tile forward-drive clutch is engaged, turning tile first ring gear. Tile Reverse-High clutch is also engaged locking tile sun gear to the ring gear and causing them both to turn at tile same speed. Planet gears cannot turn so their carrier is driven at engine speed. Output shaft turns at engine speed, giving direct drive and no torque multiplication

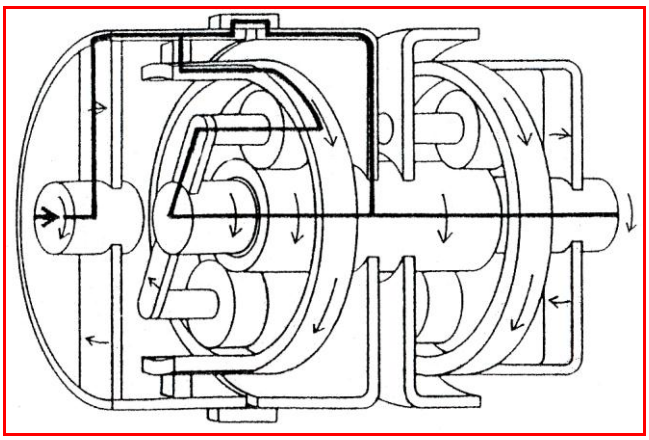

Figure 2.17: High gear

Reverse

Forward-drive clutch is disengaged, allowing the first ring gear to freewheel. Reverse-High clutch is engaged, driving the common sun gear. The second planet carrier is braked (blue arrows), so the sun gear causes the second planets to drive the second ring gear in the opposite direction, giving one speed reduction and reverse drive to back up the car

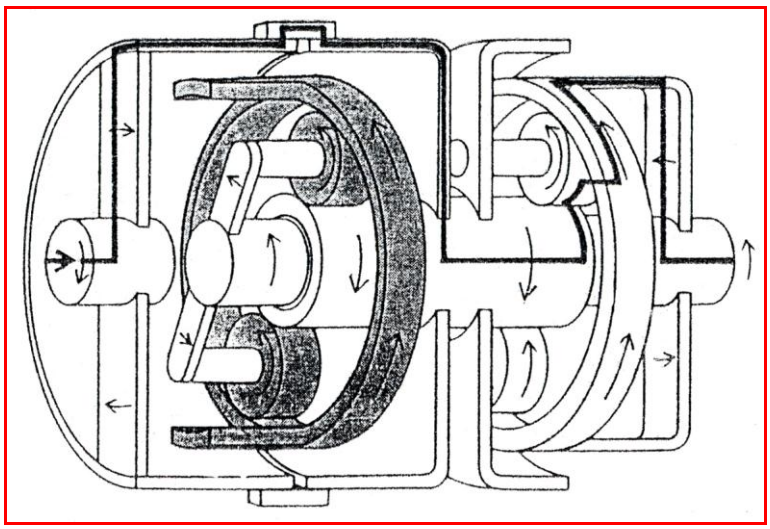

Figure 2.18: Reverse gear

2.2.6.5. How Does An Automatic Transmission Shift Gears?

The control valve body, located at the bottom of an automatic transmission, is the "brain" that shifts the gears. It is a complex maze of passages, valves and springs that shuttles hydraulic pressure to the various pistons and servo mechanisms that engage and disengage the brakes and clutches in order to control the planetary gear sets. A pump, driven by the transmission's input shaft, draws transmission fluid from a reservoir or oil pan, at the bottom of the transmission and circulates it through the torque converter then on to the transmission fluid cooler in the radiator. When it returns from the radiator the fluid is used to lubricate the moving parts of the transmission. This same fluid, supplied under pressure to the control valve body is used to shift the planetary gears.

The control valve body receives signals on vehicle speed, throttle position, engine load, and the gear selected by the driver. It then directs fluid pressure to the appropriate servos to engage the correct gear for the particular driving situation.

When the driver puts the shift lever in drive, he moves a shift valve inside the control valve body. The shift valve directs fluid pressure to the servos that engage first gear. Two other valves automatically control the shift into second.

The throttle valve reacts to the position of the gas pedal. The governor senses the speed of the transmission output shaft and generates a fluid pressure signal that is

proportional to the car's speed. The two work against each other to shift the gears at various road speeds.

When the car is accelerating gently, throttle valve pressure is low, so that little pressure from the governor (low vehicle speed) is needed to force the shift valve into Second. At wider throttle openings, during rapid acceleration, higher pressure from the governor is countered by higher pressure from the throttle valve, blocking the shift until higher engine and vehicle speed are achieved. This is how an automatic transmission can shift gears at low engine speeds to save fuel during gentle driving or hold the transmission in a lower gear when maximum acceleration is desired. The same system provides the kick down into a lower gear when you floor the accelerator pedal. The shift from Second to High is made in the same way.

Many transmissions also use a vacuum modulator, which responds to intake manifold vacuum in order to modify the action of the throttle valve. During hard acceleration the modulator causes the throttle valve to increase fluid pressure, which applies the brake bands and clutches more tightly. During gentle driving, it lowers the pressure for smoother shifts.

2.2.6.6. Overdrive gearing and lockup transmissions

Overdrive gearing improves fuel economy and reduces both engine wear and noise by lowering engine rpm in relation to road speed. An overdrive gear set is one with a ratio of less than 1:1 (such as 0.85: 1). That is, for every 0.85 revolutions of the input shaft, the output shaft makes one full revolution.

Overdrive can be achieved by attaching a separate two-speed transmission (one of them over drive) to the rear of the primary transmission. 1t is easier and less expensive to design a four- or five-speed manual transmission in which high gear has an overdrive ratio.

Cars with rear engines or front-wheel drive usually have a combined transmission and differential unit called a transaxle. A manual transaxle has what is known as all-indirect gearing. Power enters the transaxle at one end, is transferred by gear sets to an output shaft, and exits from the same end it came in. There is no countershaft; and it is impossible to connect the input and output shafts directly for high gear as is done on a front-engine/rear-drive car. Since two gears are required to obtain high in an all-indirect transmission, it is as easy to make them overdrive as not and many front-wheel-drive cars with manual transmissions do use over-drive on fourth and/or fifth speeds.

A benefit similar to overdrive gearing can be achieved on an automatic transmission by a device that mechanically locks the impeller and turbine together at speeds over 40 mph, to eliminate the usual slippage between them. In the Torque flite transmissions used in American Motors, this is accomplished by a spring-loaded piston that presses the turbine and converter cover together at high speeds. A friction surface on the converter cover causes the two units to lock together like a clutch.

Ford's Automatic Overdrive transmission has a shaft that runs from the converter cover to an extra clutch at the rear of the transmission. At high speeds, this clutch locks the

converter cover to the transmission output shaft to eliminate slip and improve fuel economy. Fourth gear has an overdrive ratio. Toyota also offers a four-speed automatic transmission with overdrive gearing but it has no lockup feature.

2.3. The Differentials

2.3.1. Passing Power on the Wheels

The rear end in a front-engine/rear-drive car is the last major link between engine and wheels. It does three jobs: turning the flow of power 90 degrees, stepping down engine revolutions a final time and dividing power flow between the rear wheels so that one wheel can turn faster in order to go the long way around the outside of a curve while the other slows down to follow the shorter inside path. The rear end is sometimes called the final drive or differential.

When a direct-drive transmission is in high gear, the drive shaft turns at the same speed as the engine-usually between 2,500 and 4,000 rpm at 55 mph (90 km/h). But at 55 mph the wheels and tires need to turn at only 600 to 950 rpm, depending on their size. The ring gear and pinion gear make this speed reduction, as well as changing the direction of the power flow by 90 degrees.

It takes several revolutions of the pinion to turn the ring gear once. This gives the last gear reduction from engine speed to wheel speed-usually a ratio ranging from 2:1 to 4:1, depending on car size, weight and use. High gears (low numerical ratios like 2: 1) give good fuel economy and low gears (high numerical ratios like 4:1) increase acceleration and pulling power. The ratio selected by car designers is a compromise between power and economy, always deliberately worked out to an odd number-for instance, not 4: 1 but 4.11:1. The odd number means that a given tooth on the pinion mates with the same tooth on the ring gear less often than it would if the ratio were an even 4: 1. An imperfection on two matching teeth is therefore much less likely to cause a failure than if the two bad spots hit on every fourth revolution.

Dividing power between a fast-turning outside wheel and a slower-turning inside wheel is the job of the differential-four gears mounted in a cage that is turned by the ring gear. One side gear is splined to the end of each axle shaft. Two pinion gears are meshed with the side gears and attached to the cage. When the car is driven straight ahead the ring gear turns the cage, which turns the pinions and the axles. When the car rounds a curve, the pinions roll around the side gears so that the inside wheel can turn more slowly and the outside one can speed up. The ring gear and cage turn at the average speed of the two wheels.

2.3.2. Front –Wheel Drive

The idea of pulling a car by the front wheels instead of pushing it from behind has intrigued car designers for years. The main advantage of front-wheel drive is that it concentrates all the mechanical parts into a compact package in the nose, leaving up to 80

percent of the car's volume free to accommodate passengers and luggage. Putting the engine weight over the drive wheels also improves stability and traction.

Combining the engine, transmission, and differential in one package eliminates the drive shaft and the hump in the floor that is needed for drive shaft clearance. Axle shafts connect the differential to the front wheels. Both ends of these shafts have constant-velocity (CV) joints which, unlike U-joints, produce smooth, vibration-free rotation even when they are bent at large angles.

Manual transmissions for front-drive cars are usually the all-indirect type. Power enters and leaves the transmission at the same end. The output shaft drives the differential's bevel ring gear directly if the engine is mounted longitudinally. It drives a helical differential gear if the engine is mounted transversely. Automatic transmissions in front-drive cars are often driven by heavy chains similar to those used to drive the camshafts on many engines.

Smaller front-drive cars have four-cylinder or V-6 engines placed transversely, with the transmission in line with the engine. Axles of different length behind the engine-transmission package drive the front wheels. General Motors automatics have the transmission along-side the engine.

Nearly all front-drive cars use some version of Mac Pherson strut front suspension and some have fully independent rear suspensions as well, to increase passenger and luggage space and to improve ride and handling.

Front drive saves weight by eliminating the drive shaft and live axle, but it requires relatively expensive CV joints and complex transmissions. The axle shafts should be of equal length so that the amount of torsional windup is the same on both sides of the car. Otherwise, steering would be affected every time the amount of torque transmitted to the axle shafts was increased or decreased.

It is often convenient to place the engine, clutch, and transmission in a line across the width of the car, which results in axle shafts of different length. There are two ways to resolve this problem: The engineer can make the short shaft solid and the longer one hollow so that both wind up at the same rate or he can design two similar axles with a short connecting shaft between them. Volkswagen, Honda, Chrysler and small GM front-drive cars have transverse engines with axle shafts of unequal length. Ford's Fiesta and GM's longitudinal front-drive V-6s and V-8s use connecting shafts.

The axle shafts turn the CV joints that drive stub axles to turn the wheels. These stub axles fit through hubs in the front suspension, which support the car's weight. Since the bearings in these hubs must also handle steering loads, maintain wheel alignment, and transfer road shocks to the suspension, they must be robust and precise. Special twin-row ball bearings or two single-row bearings pressed into the hub do the job.

APPLICATION ACTIVITY

Use technical English about the automotive power transfer parts.

Steps of process	Suggestions
➢ Find a text about this process and translate. ➢ Translate the text given below	➢ Please read all of the text. ➢ If you do not know words in text, research the meaning during translation ➢ Use English dictionary for the meaning of words from English to Turkish ➢ You can find detailed information about the technical words in the text. ➢ Make research about automotive power transfer parts

A clutch is necessary to assist in smooth starting, shifting gears and allowing the car to be stopped without putting the transmission in neutral.

The clutch is designed to connect or disconnect the transmission of power from one working part to another- in this case, from the engine to the transmission.

Automobile clutches in use today are of the single plate, dry disc type. One type uses a coil spring as a means of loading the pressure plate. Another type uses a diaphragm spring.

The engine must have a transmission (torque multiplier) to adapt its available torque to meet changing road and load conditions.

Torque multiplication is accomplished through the use of transmission gears. By arranging a movable set of various sized gears, it is possible to secure any reasonable degree of torque multiplication.

Transmissions are generally equipped with helical gears to assure longer life and quieter operation. One gear (low) may be of the sliding type, or all forward gears may be of constant mesh design. A synchromesh unit is designed to provide smooth gear shifting without clashing or grinding. The transmission consists of the input and output shaft assemblies, the cluster gear and the reverse idler assembly. All are housed in a strong steel or aluminum housing. The gears are selected either by a floor shift or steering wheel column shift control.

The differential contains axle side gears, pinions, a pinion shaft and the case itself. The differential drives both axles while allowing their speeds to vary. A special traction differential improves the performance of the differential under adverse conditions.

The differential unit is supported by the differential carrier, and it revolves in tapered roller bearings. A large ring gear is bolted to the case. A pinion gear, supported on a shaft in the carrier, drives the ring gear.

CHECKLIST

If you have behaviors listed below, evaluate yourself putting (X) in “Yes” box for your earned skills within the scope of this activity otherwise put (X) in “No” box.

Evaluation Criteria	Yes	No
1. Have you ever had the knowledge of technical English about the car clutches?		
2. Have you ever had the knowledge of technical English about the car gearboxes?		
3. Have you ever had the knowledge of technical English about the car differentials?		
4. Did you make research on the subject?		

EVALUATION

Please review your "No" answers in the form at the end of the evaluation. If you do not find yourself enough, repeat learning activity. If you give all your answers "Yes" to all questions, pass to the "Measuring and Evaluation".

MEASURING AND EVALUATION

Read the sentences and answer the questions. Then, compare your answers with the answer key at the end of the module.

1. Which one is power transfer part of automotive?
- **A)** Clutches
- **B)** Gearbox
- **C)** Differentials
- **D)** All

2. Which one is an advantage of diaphragm clutch?
- **A)** Smoother pedal effort
- **B)** Better cooling
- **C)** Good resistance to centrifugal force
- **D)** All

3. Which one is a kind of linkage pedal system that is used on the clutch?
- **A)** Mechanical linkage
- **B)** Hydraulic operation
- **C)** Cable operation
- **D)** All

4. Which position of the transmission is not the transfer of the engine speed to differential?
- **A)** First gear
- **B)** Reverse
- **C)** Neutral
- **D)** All

5. Which one is used with together automatic transmission?
- **A)** Diaphragm clutch
- **B)** Coil-spring clutch
- **C)** Torque converter
- **D)** All

6. Which one improves fuel economy and reduces both engine wear and noise according to road conditions?
- **A)** Hydraulic operation
- **B)** Hydraulic clutch
- **C)** Overdrive gearing
- **D)** All

EVALUATION

Please compare the answers with the answer key. If you have wrong answers, you need to review the Learning Activity. If you give right answers to all questions, pass to the next learning activity

LEARNING ACTIVITY-3

AIM

You will use the technical English about automotive movement control systems.

SEARCH

- Research the basic definitions and terms with the relevant automotive movement control systems using automotive services in your surroundings and at your school workshops and what happening with the equivalents of technical English. Bring into a report the results of making research. Make a presentation to your teacher and your friends in your classroom.

3. AUTOMOTIVE MOVEMENT CONTROL SYSTEMS

3.1. Brake System

3.1.1. How the Brakes Stop a Car

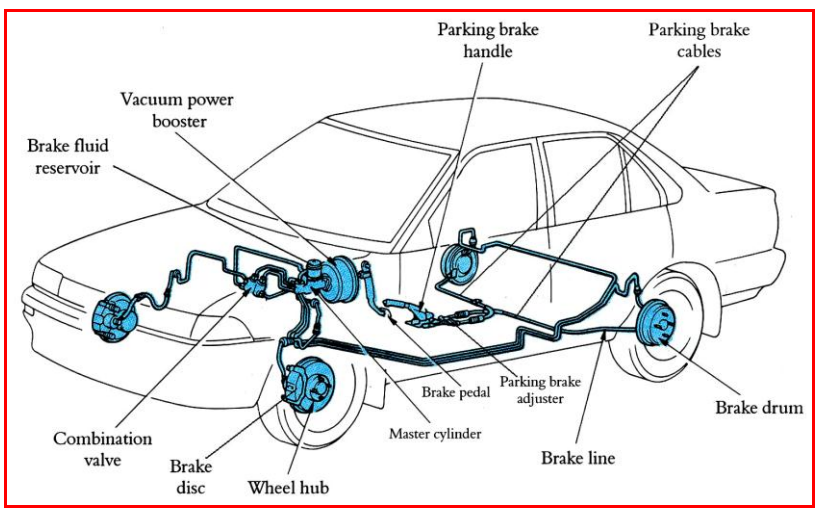

Figure 3.1: A Typical brake system

Brakes stop a car forcing a high-friction material against spinning iron discs or drums that are bolted to the wheels. This friction causes the car to slow down and eventually to stop.

Two kinds of brakes are used on modern cars-disc brakes and drum brakes. Disc brakes work by forcing pads of friction material against the sides of a spinning iron disc. Drum brakes work by farcing curved lengths of friction material against the inside of an Iran drum. Of the two, disc brakes are the more effective because the disc is exposed to a cooling now of air.

When the friction material (called brake /lining) rubs against the brake disc or drum, it creates heat. If this heat cannot be dissipated fast enough, the brake overheats and ceases to function. This phenomenon is called brake fade.

The front brakes supply up to 80 percent of a car's stopping power, making them more susceptible to overheating than the rear brakes. Because disc brakes are less inclined to fade, they are used on the front wheels of most cars. Some high-performance cars and heavy luxury cars have disc brakes on all four wheels.

The friction material is pressed against the brake disc or drum by a hydraulic system. The brake pedal is attached to a master cylinder and each brake is operated by a wheel cylinder. These cylinders are connected by a system of pipes and hoses filled with hydraulic fluid.

Hydraulic brakes work on the principle that pressure on a liquid in a closed system is equal throughout the system. When the driver pushes the brake pedal, a piston moves against the fluid in the master cylinder, and this applies equal force at all four wheel cylinders. Pistons inside the wheel cylinders press the linings against the discs or drums.

The hydraulic system can also increase the pressure applied by the wheel cylinders. If the surface area of the piston in the master cylinder is half of that of pistons in the wheel cylinders, the pressure applied to the wheel cylinders doubles. But the distance the wheel cylinder piston travels will be only half that of the master cylinder's piston. Since only a tiny movement is needed to press the linings against the disc or drum, 2 inches of pedal movement can greatly increase the pressure that the driver's leg muscles apply to the brake pedal.

In addition, leverage in the brake pedal can be employed to double or triple the pressure applied to the master cylinder by the driver's leg. Power brakes increase this even further by using engine vacuum to multiply the force applied to the master cylinder by the brake peda1.

The parking brake holds the car in place when it is not being driven. It is a mechanical system of levers and cables that applies the rear brakes. A foot pedal or hand lever applies the brakes, and a ratchet gear holds them on. A knob or button disengages the ratchet and releases the brakes. The system is mechanical because hydraulic systems tend to leak slightly if made to hold high pressure for long periods of time.

A light on the dashboard tells the driver when the parking brake is on. It also serves as a warning light to signal the lass of pressure in the hydraulic system, either because of a leak or because the fluid level is low in the master cylinder's fluid reservoir.

3.1.2. Disc Brakes

A disc brake consists of a east-iron disc or rotor and a caliper that clamps friction pads against it. The rotor turns with the wheel. The caliper is mounted on the front suspension. Most disc brakes have sliding calipers. These are mounted so that they can slide from side to side a fraction of an inch. When the driver steps on the brake pedal, hydraulic pressure pushes on a piston inside the caliper and it pushes the brake pad against the rotor. Reaction to this pressure moves the whole caliper on its mounting, pulling the other brake pad against the rotor too.

Older ears used fixed-caliper brakes, which required two or four hydraulic cylinders per wheel. The single cylinder makes the sliding-caliper brake cheaper to manufacture and more reliable because it has fewer hydraulic seals.

The big advantage of disc brakes is their freedom from fade. Brakes fade when they get so hat that the lining material loses its high-friction qualities. Disc brakes transfer heat to the air more rapidly than enclosed drums do. As it heats up and expands the rotor becomes fatter, thus increasing the pressure against the pads, rather than expanding away from the linings as a drum can. Water and dirt are thrown off the rotor by centrifugal force, which makes for even braking under ad verse conditions.

The disadvantages of disc brakes, compared to drum brakes, include the lack of any built-in servo or power-increasing ability. Disc-brake pads are smaller than drum-brake shoes, so that disc linings wear faster. However, power-brake boosters make disc brakes easy to apply and easily removed sliding calipers make pad changes simple.

Some disc brakes have pad-wear indicators. The most common type has a spring mounted on the pad. When the pad wears down, the spring rubs on the rotor and squeals.

3.1.3. Drum Brakes

Drum brakes use a pair of semicircular shoes that rub against the inside surface of a metal drum to slow and stop the car. The drum turns with the wheel. The shoes are mounted on a backing plate that is attached to the axle housing or suspension so that it does not turn. When the driver steps on the brake pedal, hydraulic pressure is developed in the master cylinder and delivered to each wheel cylinder. The wheel cylinders push one end of each brake shoe against the drum. The other end of the brake shoe is supported by a pivot point called the anchor.

The anchor of ten incorporates the brake adjuster. As the friction material lining the shoes wears down, the shoes must he moved closer to the drum in order to maintain full braking force. This is done by a screw-type adjuster that moves the pivot points closer to the

drums. On same ears this adjustment must be made manually at intervals of 3.000 to 6.000 miles (5,000 to 10,000km).

Most modern cars have disc brakes on the front wheels and drum brakes at the rear. Disc brakes are all self-adjusting so it makes sense to incorporate self-adjusters in the rear drums that must work with them. Self-adjusters usually operate whenever the brakes are applied while the car is backing up.

3.1.4. Power Brakes

Power brake boosters help the driver push the brake pedal. Most designs utilize vacuum from the engine's intake manifold to develop the power.

The vacuum power booster is around, stamped-steel canister mounted on the fire wall between the brake pedal linkage and the hydraulic system's master cylinder. Inside the canister are a rubber diaphragm, a return spring, and some valves. The valve-operating rod, which is moved by the brake pedal, pushes on the end of another rod that moves the master cylinder pistons. If the power booster fails, the brakes will still work. However, it takes greatly increased pressure on the pedal, perhaps all drivers weight, to operate the brakes if the booster fails. People may mistakenly assume that they have no brakes in these circumstances.

Equal vacuum is supplied to both sides of the diaphragm until the driver steps on the brake pedal. This moves the operating rod, opening the atmospheric port as it closes the vacuum port. Air at normal atmospheric pressure (14.7psi. or 101kPa) enters the chamber on the back side of the diaphragm in proportion to the valve openings. This pushes on the diaphragm to augment the pressure on the operating rod from the driver's foot. When the brake pedal is released, the return spring re-centers the diaphragm, opening the vacuum port and closing the atmospheric port to reestablish equal vacuum on both sides of the diaphragm. Diesel engines and turbocharged gasoline engines produce no vacuum in their intake manifolds. Power brakes and other vacuum-operated accessories on these vehicles can be run by an engine-driven vacuum pump. Some cars have no vacuum booster but use a hydraulic brake booster pressurized by the power steering pump.

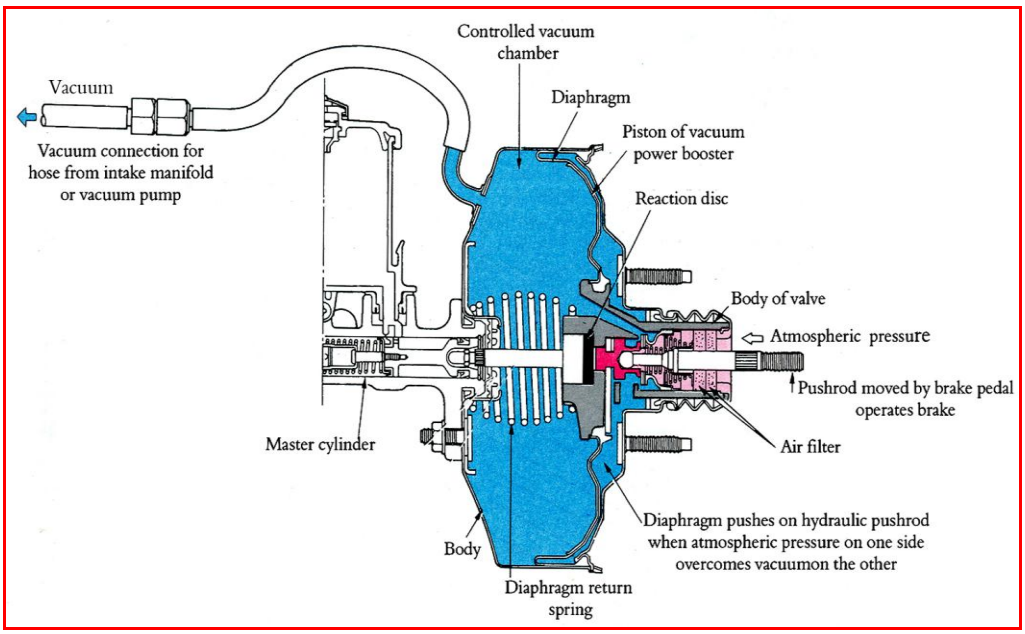

Figure 3.2: Vacuum power booster assembly

3.1.5. Fail-safe Hydraulic Brake Systems

Simple hydraulic brake systems are quite reliable. However, any leak in the system can result in a complete loss of the car's braking ability. Thus, on the theory that two independent brake systems on the same vehicle are not likely to fail at the same time, major ear manufacturers have been installing dual brake systems in their vehicles since the mid-1960s.

The master cylinder of a dual brake system has two pistons. These move in tandem when the brake pedal is depressed. Each piston pressurizes its own half of the split hydraulic system and applies braking power to two of the car's wheels. In diagonally split systems, the left front and right rear brakes and the right front and left rear brakes are coupled. In front-to-rear split systems the front and rear brakes are paired with each other.

The efficiency of either system is improved by the inclusion of valves in the brake lines between the master cylinder and the wheels. These are:

A pressure-differential valve, shown at bottom right, is also known as a brake failure warning switch. It is located below the master cylinder. This valve lights a bulb on the dash if either half of the system loses hydraulic pressure. On most cars it is easy to check whether the bulb is working, because it doubles as a parking-brake warning light.

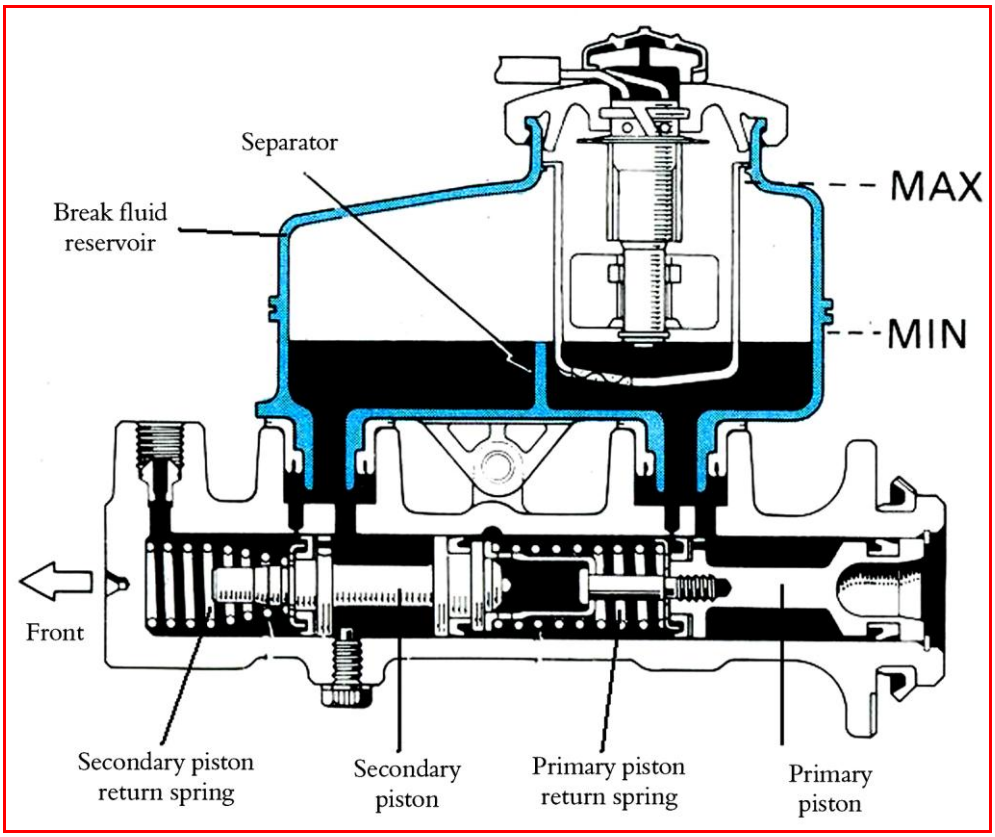

Figure 3.3: Part of master piston

A metering valve, used only on disc brake systems, causes the rear brakes to be applied before the front ones. If the front wheels are braked firstly, the car could be thrown into a skid.

A proportioning valve, used only on front-to-rear split brake systems, restricts hydraulic pressure to the rear brakes so that the rear wheels will not lock during a hard stop, thus causing a skid.

A combination valve (or control valve) is a pressure-differential valve, metering valve, and proportioning valve combined into a single unit. Combination valves are fitted in most large, late-model North American cars and are found below the master cylinder.

3.1.6. Actuation Systems

There are three main types: Hydraulic, Air-Hydraulic, Air.

3.1.6.1. Hydraulic

The transmission of the pressure that is generated by stepping on the brake pedal, from the master cylinder to the wheel cylinder, is performed by a special fluid.

The fluid pressure is boosted normally by an assisting device that uses either intake pressure or vacuum pressure.

The fluid pressure transmitted from the master cylinder is boosted by the difference between the engine-intake-negative pressure and the atmospheric pressure. Such a device is commonly called a power brake.

The hydraulic braking actuation system is to-day confined to light trucks. IVECO applies it on S range. In the hydraulic brake system, when a fluid leak occurs anywhere in the system, there is a very real danger of a complete brake loss. To reduce this danger the brake system has separate circuits for the front and rear wheels so as to ensure same braking power when a malfunction occurs (dual circuit).

3.1.6.2. Air-Hydraulic

Drums are hydraulic actuated but the first circuit between pedal and master piston is air operated. This system gives more powerful pressure. This system is normally used on 10 to 14 t GVW vehic1es.

3.1.6.3. Air

The whole circuit is fully pneumatic.

The operating principle of the air master is basically the same as that of the hydro-master, one difference being that the air-master uses compression pressure instead of engine-intake pressure as the boosting pressure. The compression pressure is produced by a compressor, which is driven by the engine and stored in an air reservoir tank.

The fully pneumatic actuation is mainly used in heavy duty vehicles because it provides a powerful servo-effect. The air-master is able to run after the engine has been stopped because of its air reservoir tank. However, when the air in the tank is depleted, it will take some time before the system is operational after the engine has been switched on.
IVECO: applies fully pneumatic braking system not only on heavy-duty vehicles but also on M range.

When the whole circuit is pneumatic, drum brakes may have two systems of operation: cam or wedge.

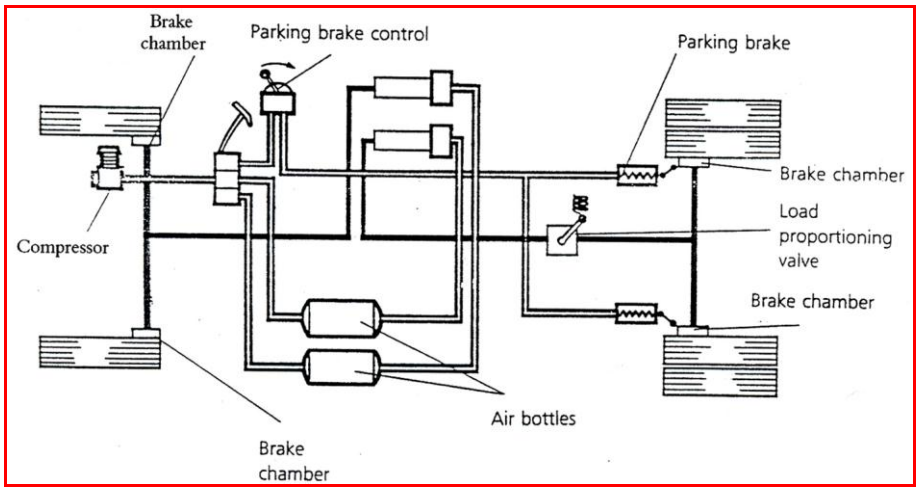

Figure 3.4: Air-hydraulic actuated

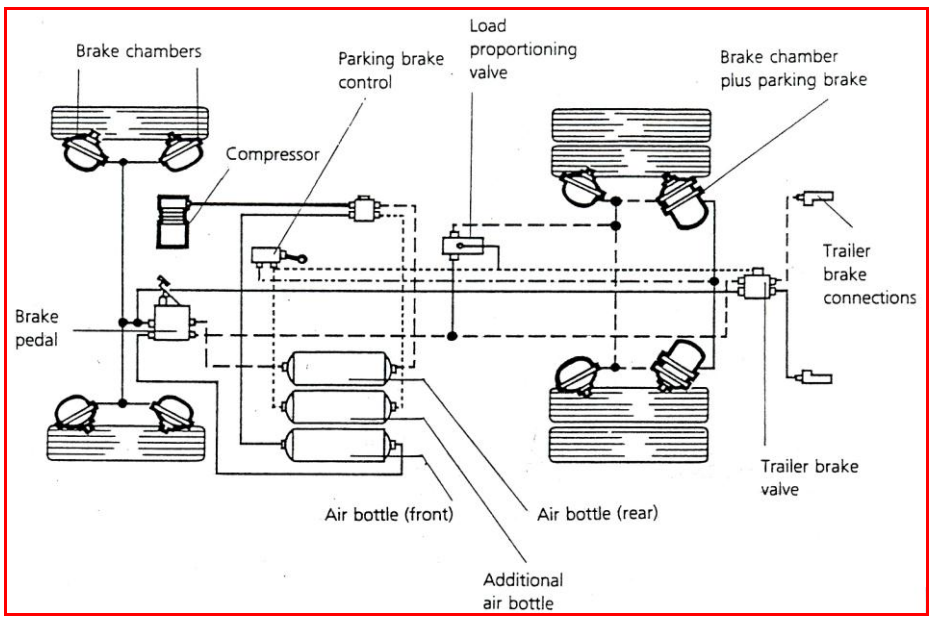

Figure 3.5: Fully pneumatic brake system

3.1.6.4. Cam

It has two shoes each pivoted at one end with a roller that rides on the cam at the other. When the brakes are applied to the cam, it rotates and the rollers move farther out on the cam radius and force the brake shoes against the rotating brake drum, slowing the vehicle. When the brakes are released, the return spring pulls the brake shoes away from the drum and the cam rotates back to its original position.

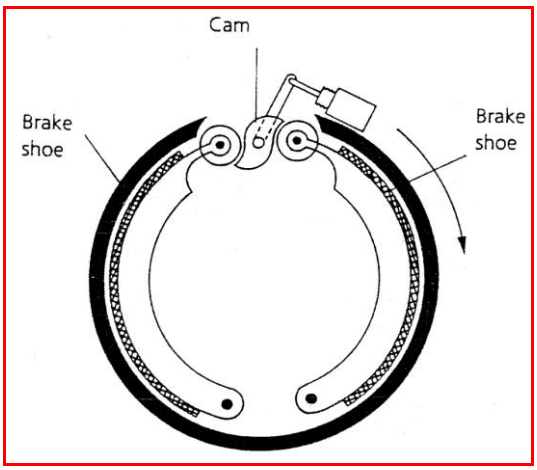

Figure 3.6: Drum brake, cam actuated (simplex)

3.1.6.5. Wedge

The wedge brake also has two shoes. In the single actuated version there is one actuator and the shoes are pivoted at the end opposite the actuator. (SIMPLEX)

In the double actuated type there is an actuator at both ends of the shoes. The shoes are not pivoted on the spider or backing plate. The wedge brake is operated by the action of the wedge being forced against plungers which push the brake shoes against the rotating brake drum slowing the vehicle. (DUO DUPLEX)

This system has by far the better efficiency. The braking action keeps its efficiency even when the truck is moving backwards because brake shoes, pushed by the two wedges, adhere completely to the drum.

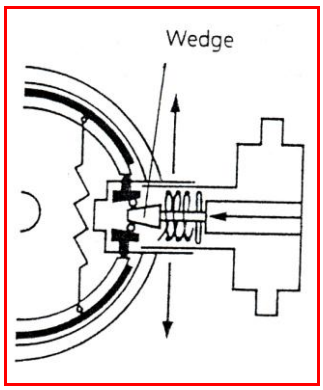

Figure 3.7: Drum brake, wedge actuated (simplex)

3.1.6.6. Brake Chambers & Adjusters

Providing the rotary motion to the cam or the linear motion to the wedge is the function of the brake chamber. It is simply a diaphragm or piston that is operated by air to move an arm (slack adjuster in the case of a cam brake) to rotate the cam or to supply the linear motion directly to the wedge. Adjustment is automatic with wedge brakes and is done internally. Cam brakes usually require manual adjustment, but automatic adjusters are available.

3.1.6.7. Parking Brake

Because it is used not only after parking, but also in starting from a slope and braking in case the foot brake fails, the parking brake is an important safety device.

- **Center-Type Parking Brake**

Because it is independently mounted on the propeller shaft it is called “center-brake". It is on old-fashioned design.

- **Rear-Wheel Parking Brake**

This is mounted on the rear wheels and expands the shoes of the service brake. Because the braking force is applied simultaneously to the rear wheels, instability in one wheel does not affect it.

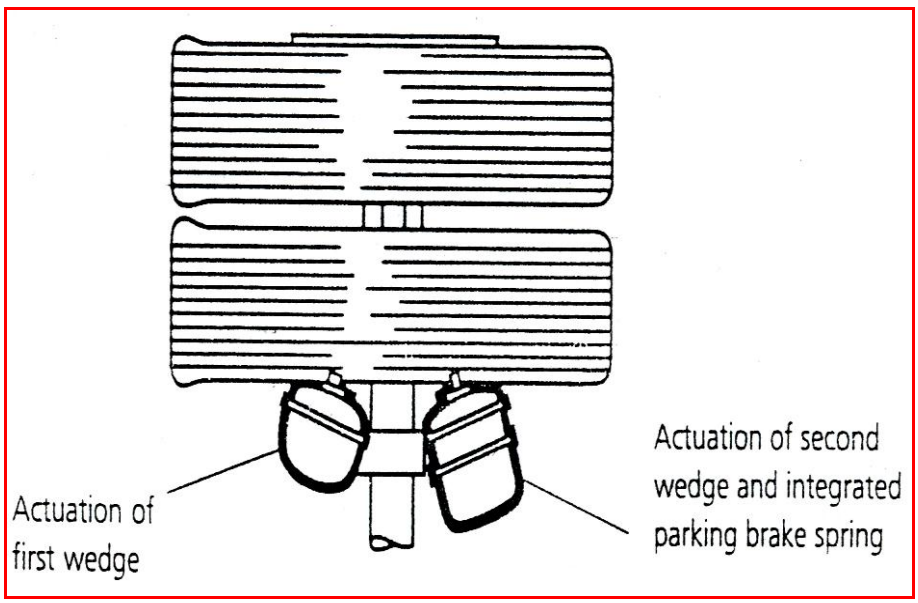

Figure 3.8: Brake chamber. (duo duplex system)

3.1.6.8. Exhaust Brake (Or Engine Brake)

Brake device using engine compression pressure as a retarding means is commonly used for partial braking while descending steep grades will increase brake shoes longevity.

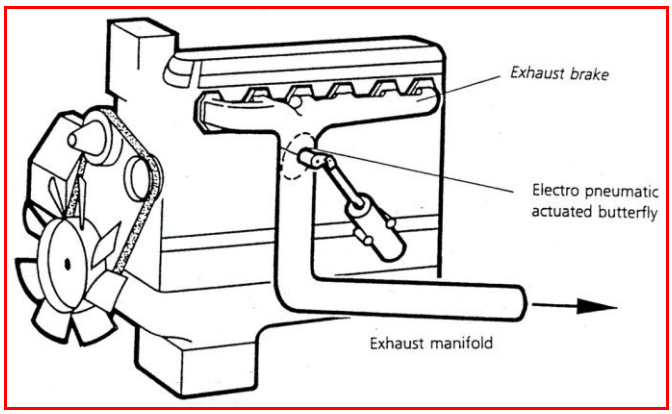

Figure 3.9: Exhaust brake

3.1.6.9. Retarder

In order to support the exhaust brake in today's more and more difficult traffic situation, where also high commercial speeds are required, a so-called retarder or better "wearless permanent brake" can be fitted as optional equipment on the propeller shaft.

There are two types of retarder:

- Hydrodynamic
- Eddy-current (electro-magnetic)

The eddy-current type uses electro-magnetic (brake) forces which are created by two propeller-shaft driven steel discs rotating in a magnetic field.

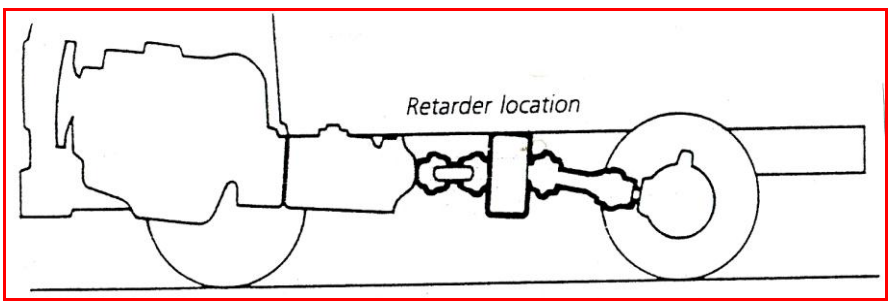

Figure 3.10: Retarder

3.1.6.10. Anti-Skid-System (ABS)

This is an electronic device that gives drivers of commercial vehicles considerable confidence for critical traffic situations and compensate for human error, e.g. in panic

braking. ABS ensures that even emergency braking on an iced-over surface with a coefficient of friction at less than 0.1 does not lock a wheel.

A too high brake pressure input is matched on all wheels to the adhesion present between tire and road surface which maintains steer ability and guarantees vehicle stability. ABS permits braking and steering at the same time. The shortest stopping distance is thus obtained with graduated braking: With combinations or articulated vehicles it also avoids the trailer swing or jack-knifing of tractive unit and semi-trailer.

How it works: The wheel sensor picks up without contact the rotation of a pole wheel moving together with the wheel hub.

The electronic central unit establishes the speed, acceleration and deceleration of the wheel as a vehicle reference speed and the related wheel slip.

As soon as certain wheel deceleration or slip threshold values are exceeded, the electronic central unit signals a solenoid central valve to limit the excessive brake pressure produced by the driver.

3.2. Steering System

3.2.1. How the car is aimed

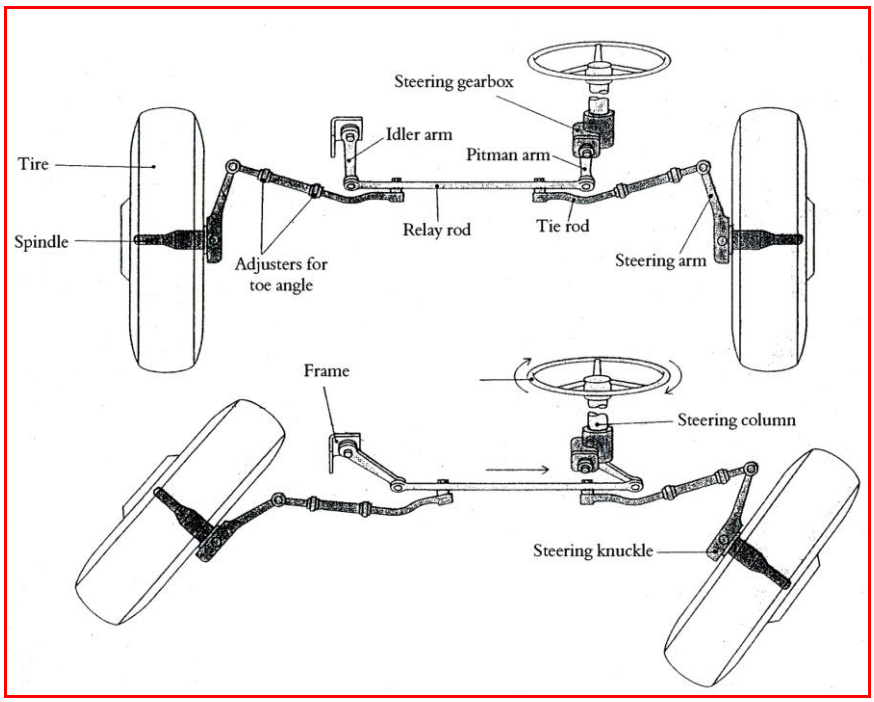

Figure 3.11: Parallelogram steering

Steering systems are designed to enable 100-pound people to control 4.000-pound vehicles quickly, accurately, smoothly, and without undue effort. This is done by a set of components that lead from the steering wheel to the front wheels.

Because the steering wheel is a small lever (its radius is only about 7 inches, or 17 cm), the driver needs a mechanical advantage to overcome the inertia of the car's weight and the friction between the tires and the road. This advantage is provided by the steering ratio-the number of 360° turns of the steering wheel that are required to swivel the front wheels from lock to lock (all the way from left to right-usually 60 degrees). For example, a ratio of 15:1 means that 2 ½ turns of the steering wheel (900 degrees) turn the front wheels 60 degrees. The steering ratio is therefore 900:60, or 15:1. A law ratio responds more quickly to the wheel but requires more power to operate than a high ratio does.

The steering shaft runs inside a tubular steering column, through the fire wall, and into the steering gearbox in the engine compartment. Modern steering shafts are designed to collapse on impact to protect the driver in a collision.

The steering gearbox converts the rotational motion of the steering wheel into the side-to-side motion of the wheels. The gears reduce the large movements of the steering wheel to the small movements of the wheel, giving the driver the necessary mechanical advantage.

The steering linkage consists of a series of rods running across the front of the car to connect the front wheels to each other and to the steering gearbox. In the parallelogram linkage used on most North American cars, the Pitman arm extends from the steering gearbox and transmits gear movement to the left end of a relay rod, which runs across the car. An idler arm, parallel to the Pitman arm, is attached to the frame to support the right end of the relay rod. Tie rods connect the relay rod to the steering arms, which transmit movement to the steering knuckles to pivot the wheels. Ball joints between the tie rods and steering arms allow steering movement to be transmitted even as the suspension moves up and down over a bumpy road surface.

Three sides of a parallelogram are formed by the relay rod, Pitman arm, and idler arm. When the wheels pivot, the parallelogram flattens out, but the opposite sides remain parallel.

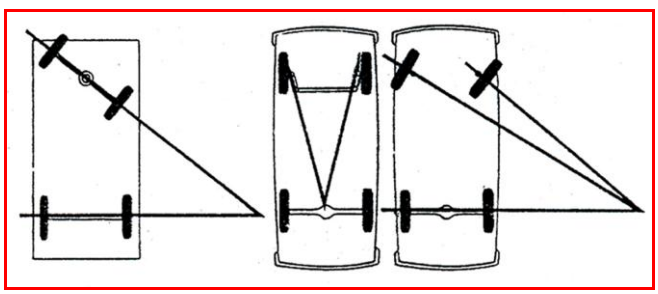

Figure 3.12: Geometrically correct

3.2.2. Manual Steering

The steering gearbox contains two gears: the driving gear, which is mounted on the steering shaft and the driven gear, which moves the steering linkage. The driving gear always turns through the same are as the steering wheel and shaft, but the larger driven gear moves through only a fraction of its length or circumference for each full revolution of the driving gear. A small force applied through a large angle at the steering wheel is transformed into a large force moving through a small angle at the steering linkage. This provides the mechanical advantage needed to turn the wheels.

Rack and pinion is the simplest form of steering. The small pinion gear on the end of the steering shaft (the driving gear) meshes with the rack (the driven gear), a long bar with teeth cut into one side. The rack runs across the car, and its ends are connected to the tie rods. Turning the steering wheel rotates the pinion, which moves the rack left or right.

The worm and roller steering gearbox is named for its component gears. The worm (the driving gear) is a spiral-threaded gear mounted on the end of the steering shaft. It meshes at a right angle with the threads of the roller (the driven gear), a wheel-shaped gear mounted on the Pitman shaft.

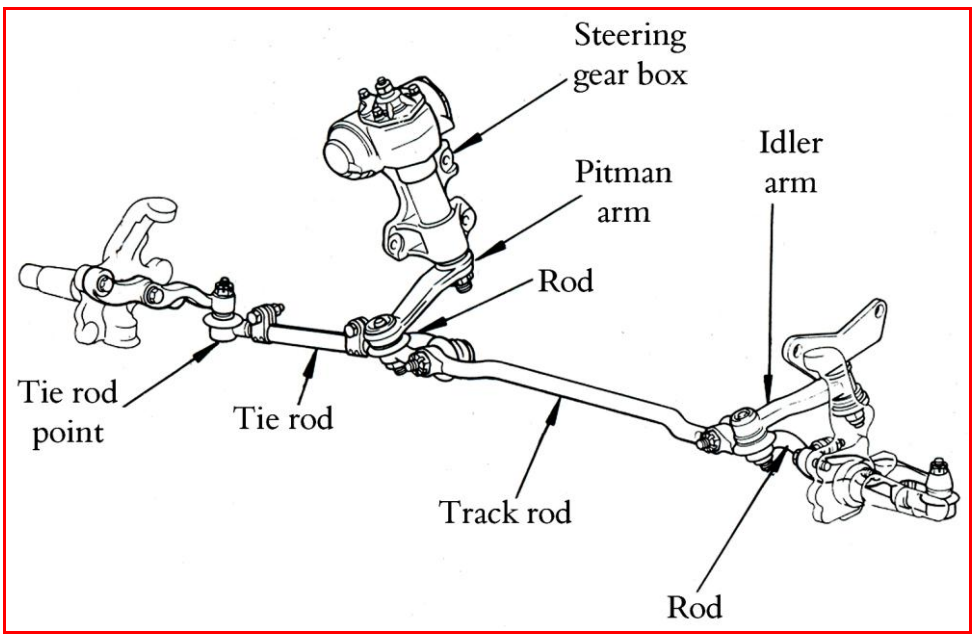

Figure 3.13: Parallelogram steering linkage

The recirculating-ball steering gearbox is designed to reduce friction between the gears. This system also uses a worm gear on the end of the steering shaft as the driving gear; but instead of engaging the driven gear directly the worm gear is threaded into a ball nut rack, like a bolt into a nut. About 40 steel ball bearings fit in the thread-like grooves between the worm gear and the ball nut rack. A tube connects the ends of the threads. The balls move

into the tube at one end and reemerge at the other end; this gives them a continuous loop to follow and prevents them from piling up at one end of the ball nut rack.

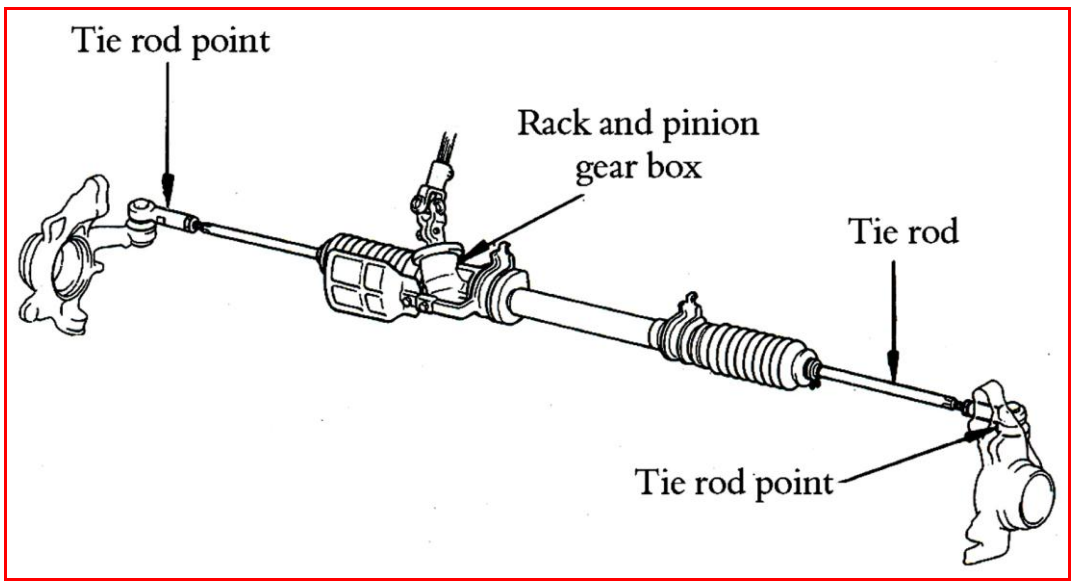

Figure 3.14: Rock and pinion steering linkage

3.2.3. Steering Gear Box

3.2.3.1. Rack and Pinion Gearbox

The pinion gear rotates with the steering shaft, moving the rack from side to side. Several full turns of the pinion are required to shift the rack from lock to lock. Because there are so few parts in the steering linkage, rack and pinion is a very precise and responsive steering system and is often used in sports cars.

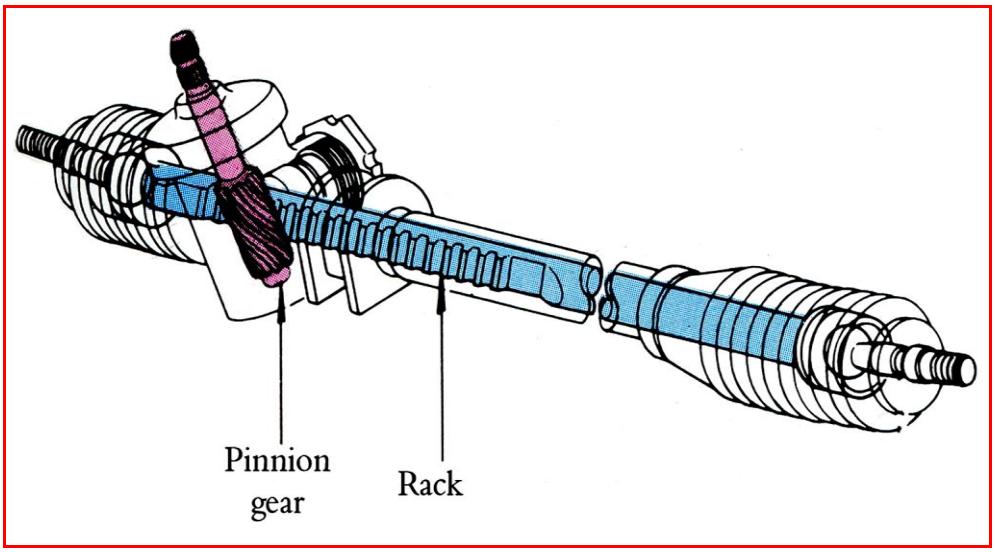

Figure 3.15: Rack and pinion gearbox

3.2.3.2. Worm and Roller Gearbox

Worm and roller gearbox is used with parallelogram linkage. Threads on the worm gear engage the threads of the roller. Both ends of the worm gear are supported by ball bearings to reduce friction. When the steering wheel is turned the roller moves along the worm gear, swiveling the Pitman shaft.

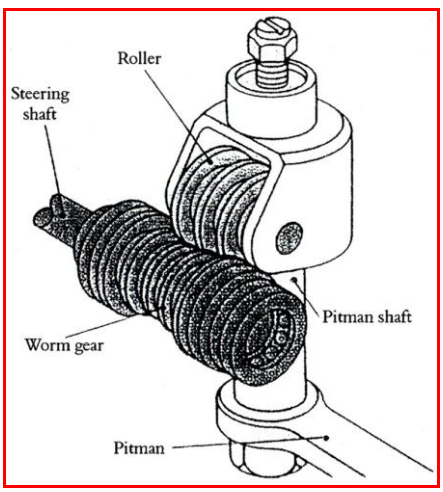

Figure 3.16: Worm and roller gearbox

3.2.3.3. Recirculating-ball Gearbox

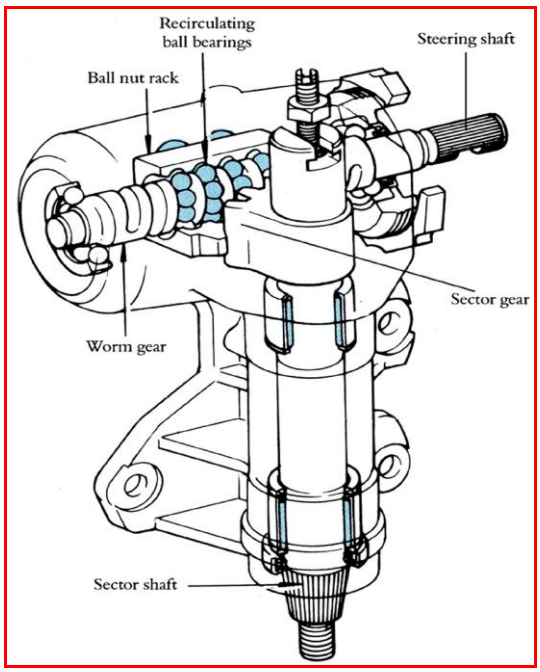

Figure 3.17: Recirculating-ball gearbox

Turning the steering wheel rotates the worm gear, which causes the ball nut rack to move up or down. Teeth on the outer edge of the ball nut rack mesh with the sector gear so that as the rack moves, it swivels the sector gear and Pitman arm. The ball bearings in the grooves reduce friction.

3.2.4. Power Steering

Power steering uses hydraulic pressure to reduce the effort needed to steer heavy cars. There are two basic systems. Integral power steering applies the pressure inside the steering gearbox. This system is used in most new cars. Linkage power steering employs a separate hydraulic cylinder to apply power assistance directly to the steering linkage. The advantage of the linkage system is that it can be attached to an existing steering system with few modifications. This is usually easier and cheaper for the manufacturer than changing the steering gearbox. An integral power steering gearbox is similar to a recirculating-ball manual steering gearbox except that the case is filled with hydraulic fluid. The ball nut rack divides this case into two chambers and serves as the piston on which the hydraulic pressure operates.

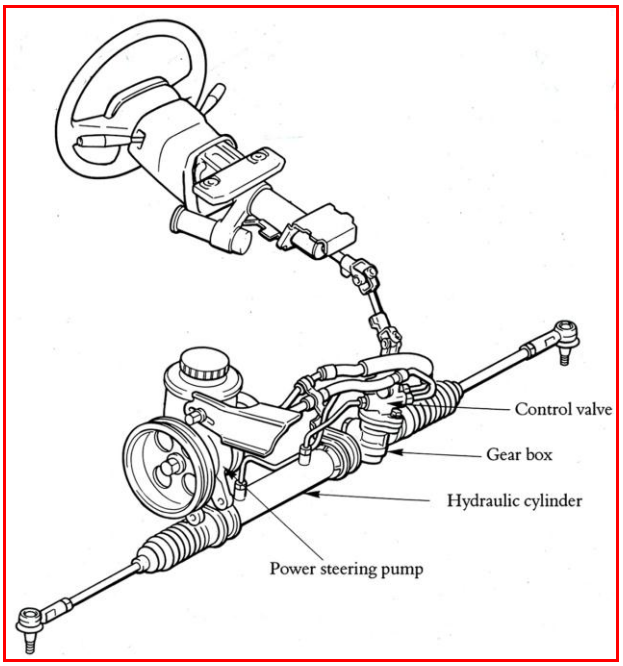

Figure 3.18: Power steering

A control valve in the gearbox, activated by the steering shaft whenever the steering wheel is turned, opens and closes passages that direct fluid into the proper chamber for a left or right turn. The control valve also directs excess fluid back to the reservoir.

Rack and pinion can be designed with power assist too. A flange on the steering rack acts as a piston and hydraulic pressure is supplied to either side of it.

The power steering pump is driven by a belt from the engine. A pressure relief valve in the pump protects the system from excess pressure when the engine is turning at high speeds.

Two hoses connect the pump to the steering gearbox. The pressure hose carries fluid under pressures as high as 1.500 psi (10,300 kPa) to the gearbox. The return hose carries fluid back to the pump at a pressure of about 50 psi (350 kPa).

Some power steering systems have variable ratios; the steering ratio changes the further the wheels turn, which speeds up parking maneuvers.

3.3. Front-back Wheel Alignment and Tires

Wheel alignment refers to all of the angular relationships between the front suspension and steering components, wheels, and frame. Five angles are manipulated by the car designer to reach a compromise between optimum tire life, fuel economy, and handling. Maximum fuel economy and tire life are achieved if the tires are perfectly upright and parallel to the direction of travel. But a car steers and handles better if its tires run at a slight angle. This

causes them to scuff along the pavement a bit as they roll, which reduces tire life and fuel economy.

Camber is the inward or outward tilt of the wheel, measured in degrees between the tire centerline and the vertical. If the wheel tilts out, camber is said to be positive; if it tilts in, the camber is negative.

Caster is the angle that the steering axis is offset from the vertical, measured from front to back. If the steering knuckle tilts toward the back, caster is positive and if it tilts toward the front, caster is negative.

Steering axis inclination is the angle that the steering axis is offset from the vertical, measured from side to side. If the upper ball joints are farther inward than the lower ones, the wheels will straighten out if the steering wheel is released while the car is moving.

Toe-in means that the front edges of the wheels are closer together than the rear edges. Toe-in counteracts the tendency of the front wheels of rear-drive cars to toe out under power. When the car is moving at highway speeds, toe-in disappears and the wheels roll straight.

Toe-out is sometimes used in front-drive cars to counteract their tendency to toe in under power. Some toe-out on turns is necessary for all cars because the inner wheel must turn at a sharper angle than the outer wheel.

Toe is adjustable on all cars. Caster and camber also are adjustable on most suspension designs.

3.3.1. Zero Camber

Zero camber means that the wheels are perpendicular to the road, so that the tire treads contact the road evenly. This position minimizes tire wear by distributing the car's weight uniformly across the tread, but steering tends to be heavy.

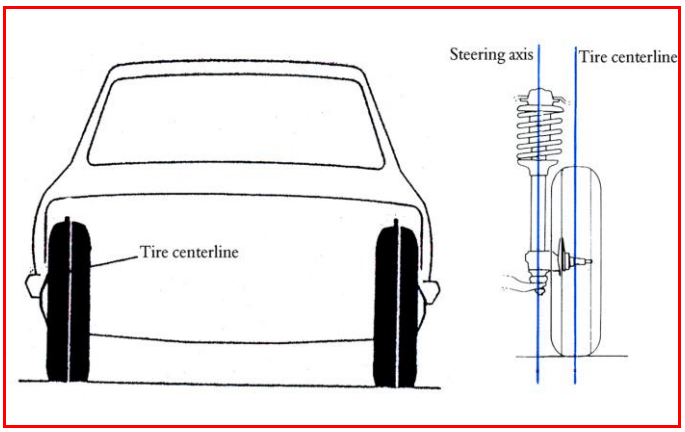

Figure 3.19: Zero camber

3.3.2. Negative Camber

Negative camber can cause the tires inside edges to wear faster than the outside edges. Independent suspension allows a small amount of negative camber when a wheel moves up going over a bump, so that the track will not vary.

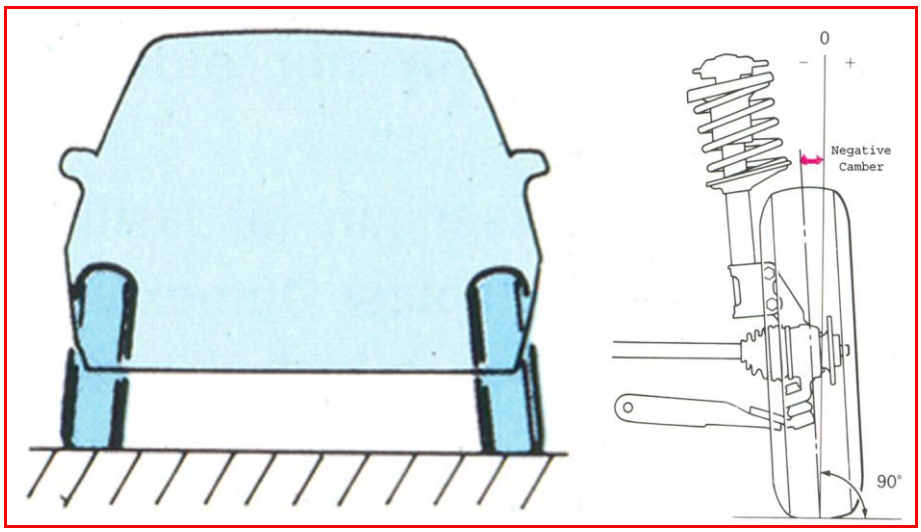

Figure 3.20: Negative camber

3.3.3. Positive Camber

Positive camber can cause the outside edges of the tires to wear taster. Front wheels often have a little positive camber in order to provide stable handling in turns on the typical high-crowned road or when the pavement is bumpy.

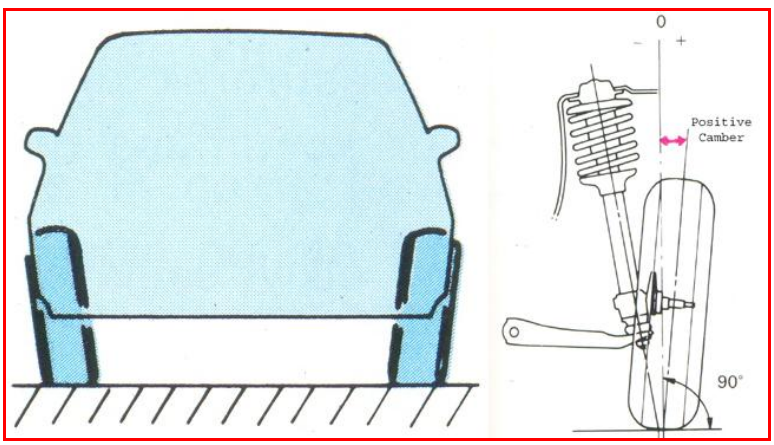

Figure 3.21: Positive Camber

3.3.4. Positive Caster

Positive caster is most simply demonstrated by shopping cart wheels. The point where each front wheel touches the ground is behind the steering axis. This puts the load in front of the wheels and they swing around to follow. The car then tends to move in a straight line unless it is deliberately steered in a different direction.

Positive caster is designed into cars for the same reason-to improve directional stability. With the steering knuckle tilted back the steering axis meets the road ahead of the midpoint of the tire's contact area and the car, like the shopping cart, lends to travel straight ahead unless the driver steers it in a different direction.

3.3.5. Steering Axis Inclination

Steering axis inclination tilts the spindles. When the wheels are straight, the spindles are horizontal. When the wheels turn, the outer ends of the spindles try to move down. Since the road prevents this the inner ends lift up the car. When the steering wheel is released, gravity forces the ear down and the wheels straighten out.

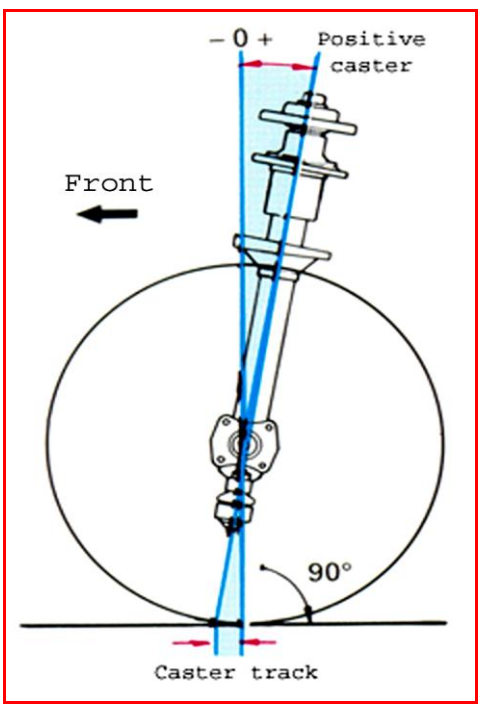

Figure 3.22 Positive caster

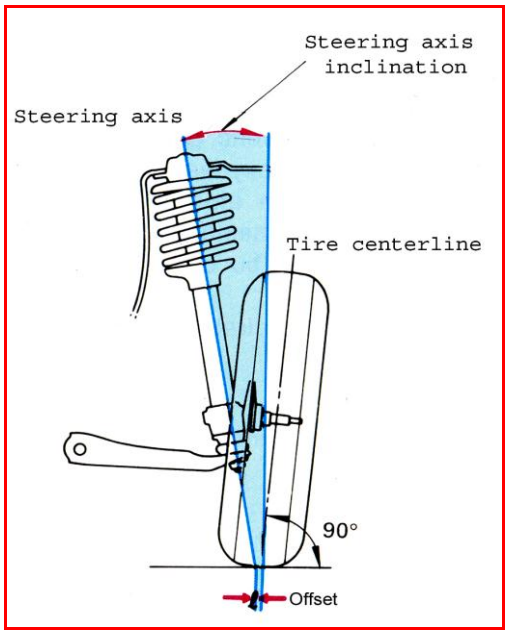

Figure 3.23: Steering axis inclination

3.3.6. Toe-in and Toe-out

If it were not for the fact that they are firmly attached to the suspension wheels that toe in would run toward one another and those that toe out would diverge. Wheels that toe in or toe out at highway speeds will scuff badly, resulting in uneven tire wear and poor fuel economy.

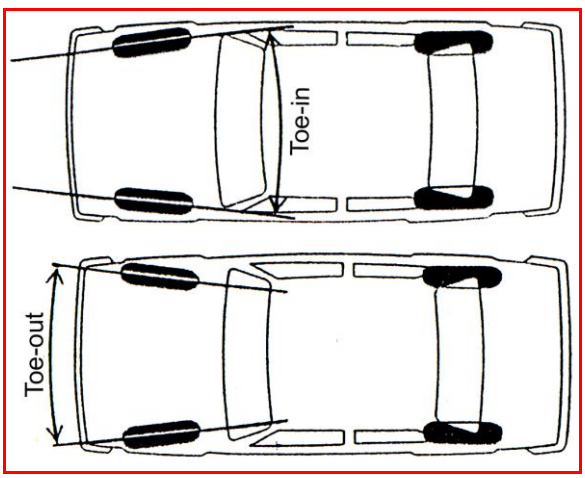

Figure 3.24: Toe-in and toe-out

Toe-out on turns allows the inner wheel to steering through a tighter angle than the outer wheel so that both wheels can turn around the same point.

3.4. The Suspension System

3.4.1. Independent Front Suspension

Virtually all modern cars have independent front suspension, which means that each front wheel is linked to the frame separately. This allows the wheels to react to the road independently so that, for example, the left wheel can go over a bump and move up while the right wheel goes into a depression and moves down without tilting the whole car. Independent suspension offers two advantages over the solid-axle suspension used on old cars and some modern trucks: The ride is more comfortable because the whole car no longer responds to each variation in road surface and handling is improved because both tires retain better contact with the road.

The front wheels must steer as well as respond to the road surface. Ball joints, which can rotate in all directions, allow the wheels to steer left or right and move up or down simultaneously. A stabilizer bar is often set between the left and right suspension components to reduce the amount the car's body leans in a turn.

Several engineering solutions to the basic idea of independent suspension are illustrated below.

Solid-axle suspension forces both wheels to react when one wheel encounters a bump. This tilts the entire car and disturbs the other tire reducing its contact with the road. Solid-axle front suspension has not been seen on passenger cars since the days of the Model T Ford, but it is still found on many four-wheel-drive vehicles. Independent front suspension allows both wheels, low react separately.

If one wheel hits a bump, its suspension absorbs most of the shock, allowing the opposite wheel to stay in contact with the road.

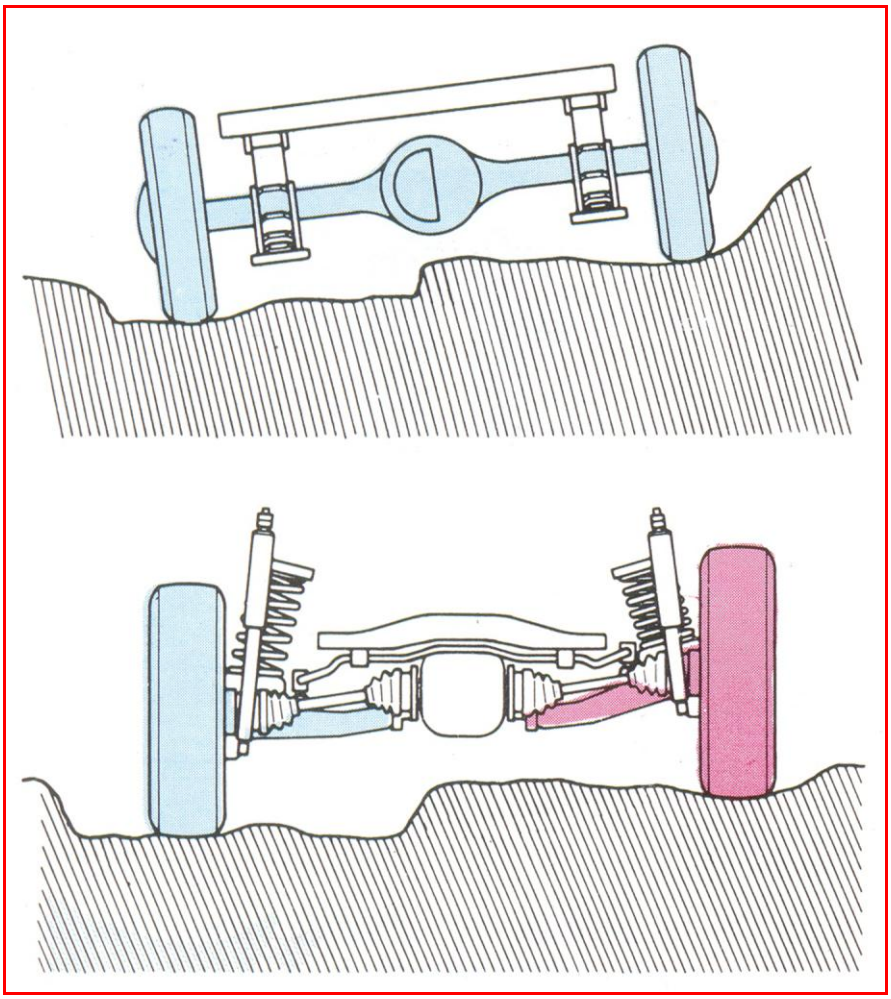

Figure 3.25: Types of suspension systems

If the upper and lower A-arms are the same length, the wheel will remain at a right angle to the road when it goes over a bump, but it will move in slightly, narrowing the track (the distance between the front wheels). Steering will be impaired, and the tires will wear rapidly if the upper A-arm is shorter than the lower the wheel will tilt inward as it moves up. The track will not vary, steering accuracy will be improved, and tire wear will be reduced. If the car is leaning into a turn, the inward tilt of the wheel will keep the tire perpendicular.

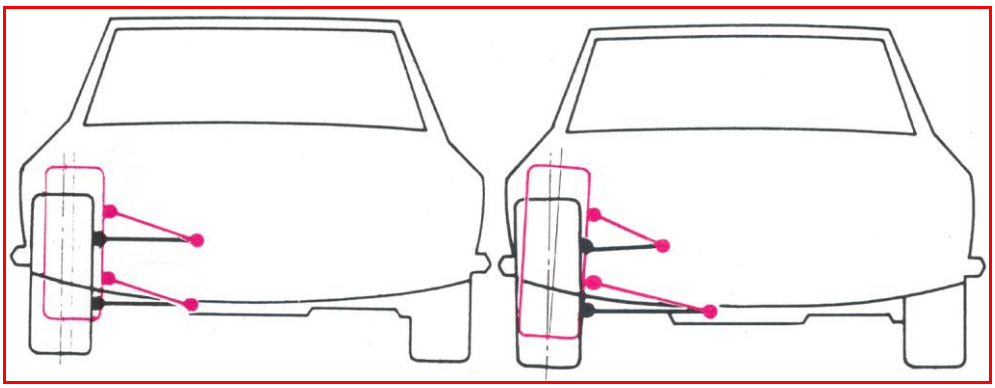

Figure 3.26: Upper and lower A-arms

A ball joint consists of a ball stud that fits snugly into a socket the ball can rotate freely in the socket but cannot slip out of it. Ball joints are placed between the steering knuckle and suspension arms. They allow movement in more than one plane so that the wheels can move up and down with the suspension and can be steered at the same time.

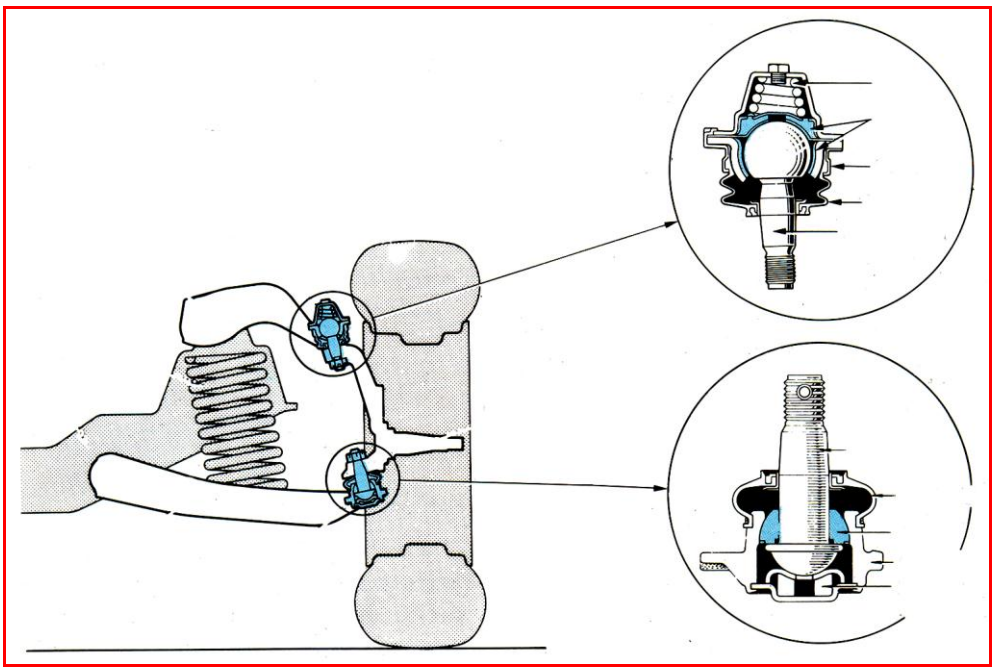

Figure 3.27: Types of ball joints

Kingpins were used on early solid-axle front suspensions because they were sturdy and allowed the wheels to pivot in one plane for steering. To be adapted to A-arm suspension systems, kingpins had to be fitted with additional pivoting members at the top and bottom. The configuration shown here was typical, with the kingpin running straight through the steering knuckle. Ball joints make for a lighter and less complex arrangement.

Torsion bars can be used in place of coil springs to absorb road shocks in A-arm suspensions. Large Chrysler Corporation cars have used torsion-bar front suspensions for decades. The rear end of the torsion bar is attached to a frame member near the fire wall and the front end is attached to the lower A-arm. Torsion bars can be adjusted to change the ride height of the car and the softness or firmness of the suspension.

3.4.2. Double A-arm Suspension

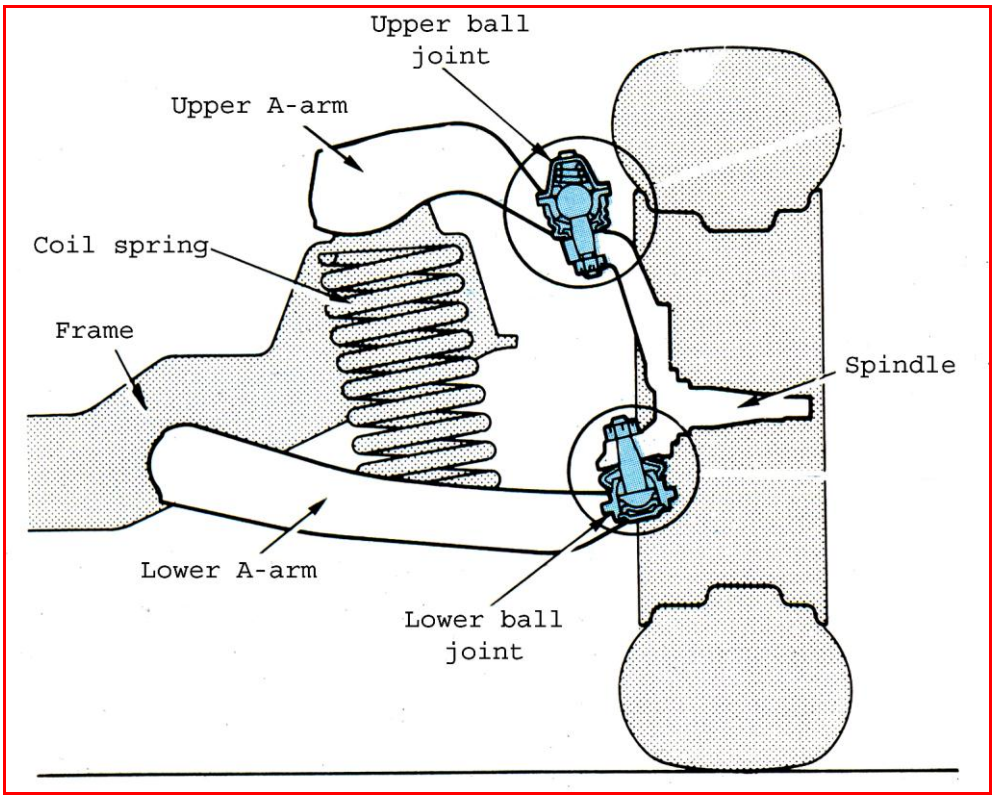

Figure 3.28: Part of double A-arm suspension system

Double A-arm suspension derives its name from the triangular upper and lower control arms that are the main supports of the wheel. The wide ends of both A-shaped arms are hinged to the frame. The narrow ends are attached to the upper and lower ball joints. The steering knuckle (including the stub axle, or spindle, that carries the wheel bearing and the wheel) is fixed between these ball joints. This configuration allows the wheel to move up and down with variations in the road surface and left and right as it is steered, while keeping the wheel in the correct position with respect to the road and the car. A spring and a shack absorber are set between the frame and the lower A-arm, or between the frame and the upper A-arm, to absorb road shock and to help control wheel movements.

3.4.3. Mac Pherson Strut Suspension

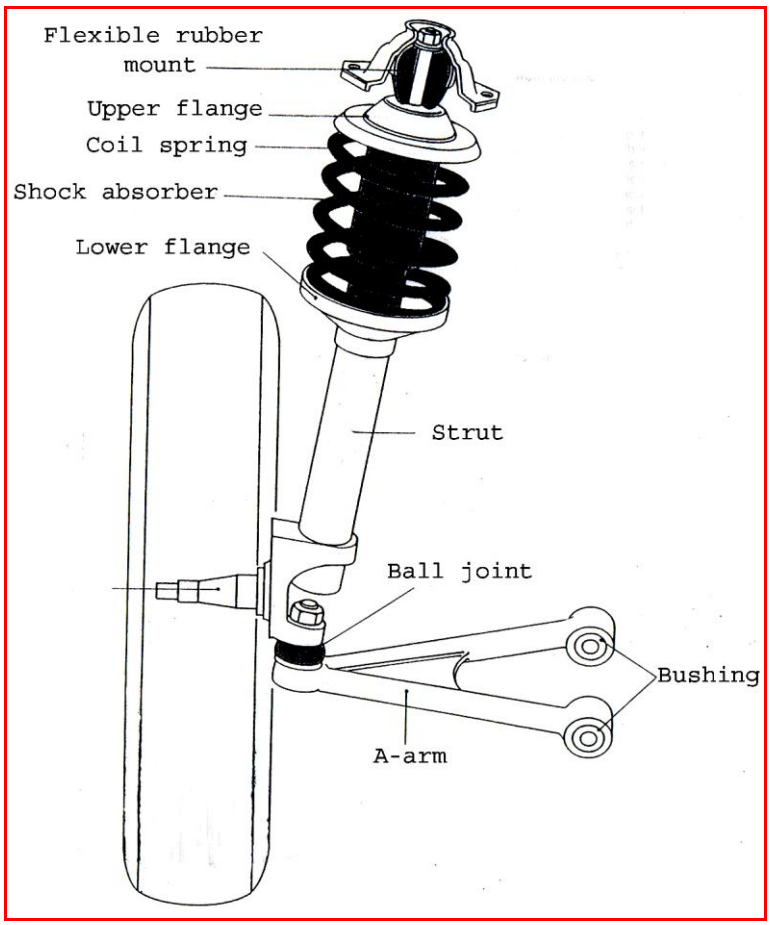

Figure 3.2: Mac Pherson strut system

The identifying feature of a Mac Pherson strut suspension is a heavy tubular strut running from the wheel to the frame. The top of the strut is flexibly attached to the frame, and the spindle that carries the wheel is bolted or welded to the lower end of the strut. When the car is steered, the entire strut turns. A coil spring surrounds the upper half of the strut and a telescopic shock absorber is set inside the spring and the strut. The strut serves as the upper suspension link. A single A-arm hinged to the frame and attached to the bottom of the strut with a ball joint serves as the lower link. Although they are compact, Mac Pherson struts may cause the car owner added expense because the springs must be removed from the car to replace the shock absorbers.

The single A-arms of a Mac Pherson strut suspension allow very little change in wheel camber (tilt from the vertical) as the wheel moves up and down over bumps, thus improving steering accuracy and increasing tire life.

Trailing arms, another variation of independent suspension, are used on the VW Beetle. This system permits the distance between the front and back wheels to vary, but camber and track do not change with the up-and-down movement of the wheels.

3.4.4. Stabilizer Bars

View (figure 3-30) from follow shows a suspension with a stabilizer bar, Mac Pherson struts and lower A-arms. This setup may cost the manufacturer less than the more complicated double A-arm system. The stabilizer bar transfers some of the braking forces from the wheel to the frame and also resists body roll in turns.

In turns, centrifugal force transfers some of the car's weight to the outside wheels. If the wheels are independently suspended, there is nothing to counter this tendency and the car leans toward the outside of the turn, making steering and handling difficult in extreme cases. To minimize this effect, the left and right A-arms are often linked by a stabilizer bar. Essentially a torsion bar that runs across the car, the stabilizer bar twists as the car leans, resisting the motion and keeping the car relatively level. It also restricts the independent action of the wheels somehow. Stabilizer bars are also called anti-sway bars, sway bars, anti-roll bars or roll bars.

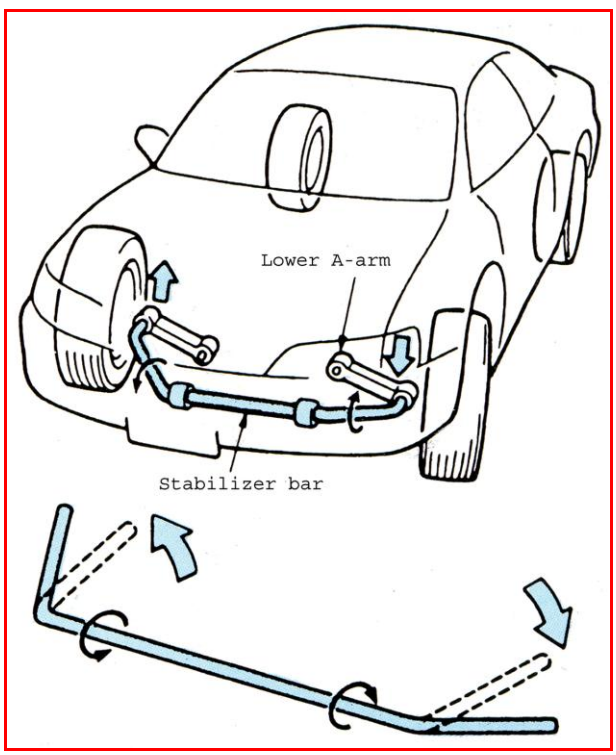

Figure 3.30: Stabilizer bar

3.4.5. Rear Suspension

Rear suspension, like front suspension, is designed to keep the wheels in contact with the road and to give the passengers a comfortable ride, so the two systems have much in common. However, some of the problems that rear suspension must resolve are unique.

The load carried by the front wheels is fairly constant: the weight of the engine and the forward sections of the body and frame. The rear wheels carry a variable load, depending on the number of passengers and the amount of cargo. Rear springs must not sag too much under added load and must not be too stiff without it. If load fluctuations are large, air-adjustable shocks may be needed.

While the front wheels must steer left and right as well as move up and down, the rear wheels should remain straight regardless of their up-and-down movement or the position of the car in turns. Instead of the ball joints used in the front suspension to al1ow the wheels to swivel freely the rear wheels are attached to the axles in a way that restricts their movement to the vertical plane.

The most important difference between front and rear suspensions is that in rear-wheel-drive cars, drive-train torque is transferred to the road through the rear wheels. Torque is the twisting force that turns the wheels and thereby moves the car. This twisting force also tries to turn parts of the suspension that must be held relatively rigid, so the rear suspension must be designed to resist torque. This is accomplished by precise placement of the suspension components and by adding control arms between the frame and the suspension. Two basic types of rear suspension have been developed for rear-wheel-drive cars: live-axle and independent rear suspension.

3.4.6. Live-axle Rear Suspension

The predominant feature of a live-axle setup is the axle housing, which runs the width of the car and bounces when either wheel hits a bump. The differential and the axle shafts are contained in the axle housing. The axle housing itself is positioned by the rear suspension.

If leaf spring is used, they locate the axle and resist sideways thrust in turns, as well as absorbing road shock. A coil-spring suspension requires control arms between the frame and the axle housing to position the axle and resist side thrust, because the coil springs can absorb only vertical forces.

Hotchkiss drive is the simplest form of live-axle suspension. No control arms are required because the long leaf springs, mounted as far apart as possible, position the axle housing and resist sideways forces. The front of each spring is attached to the frame. The middle of the spring, its stiffest part, runs under the axle housing and is solidly clamped to it with large U-bolts. The rear of the spring is attached to the frame by a pivoting shackle that allows changes in spring length but prevents sideways movement.

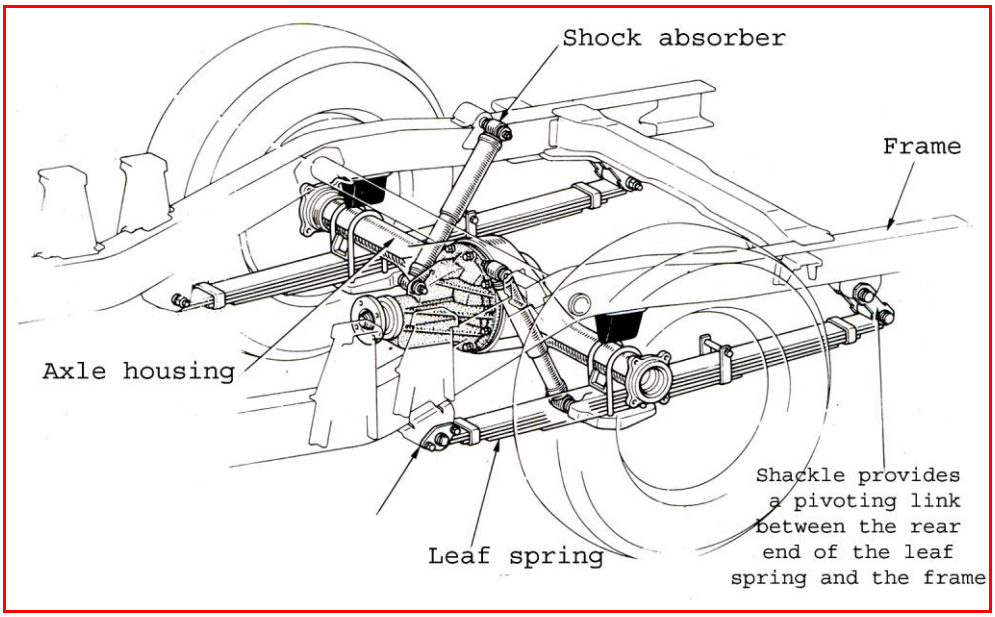

Figure 3.31: Hotchkiss suspension system

Drive-train torque and braking forces can twist the springs. Locating the axle ahead of the spring centers, or placing one shock absorber in front of the axle and one behind it, resists these twisting forces.

The stability of the rear suspension can be improved by placing pivoting control arms between the axle housing and the frame. A diagonal control arm is called a track rod or Panhard rod.

Coil springs can only absorb road shock and support weight; the axle positioning and stabilizing is done by control arms between the car body or frame and the axle housing.

Front-wheel-drive cars have no engine torque acting on their rear suspensions. Many have flexible beam axles-a form of semi-independent rear suspension. Some trunk space is lost to allow room for axle movement.

3.4.7. Independent Rear Suspension

Like independent front suspension, independent rear suspension allows each wheel to respond to the road separately. Because there is no axle housing, the differential is mounted on the car's frame. The suspension does not have to resist drive-train torque, which acts on the frame.

A common problem on older cars with simple swing-axle independent rear suspension was keeping the wheels perpendicular to the road in turns. The rear wheels would develop positive camber (tilt outward at the top), reducing the tire treads' grip on the road and in extreme cases, causing the car to skid and possibly flip over. Four U-joints and various

control-arm modifications are used in modem designs to keep the wheels nearly perpendicular to the road.

Trailing-arm independent rear suspension allows each rear wheel accommodate bumps without affecting the other wheel. Each wheel is supported and positioned by an arm that is hinged to the frame. These arms pivot at a right angle to the wheels, so that there is no camber change as the wheels move up and down. With a live axle a bump under one wheel causes a camber change in the opposite wheel.

Semi-trailing arms, a variation of trailing arms, pivot at an oblique angle to the wheels. This permits a minimum amount of camber change to be designed into the suspension.

Swing axles, the most primitive form of independent rear suspension, cause extreme camber changes because each axle with its rigidly attached wheel pivots from one U-joint.

Adding a U-joint to the outer end of a swing axle minimizes camber changes and improves handling. This change was made on Chevrolet Corvairs and VW Beetles to upgrade handling of early swing-axle models.

Front-wheel-drive cars can use the simplest of all independent rear suspension systems because their rear wheels are neither driven nor steered. Here, a trailing arm positions and supports each wheel.

APPLICATION ACTIVITY

Use technical English about the automotive movement control systems.

Steps of process	Suggestions
➢ Find a text about this process and translate. ➢ Translate the text given below	➢ Please read all of the text. ➢ If you do not know words in text, research the meaning during translation ➢ Use English dictionary for the meaning of words from English to Turkish ➢ You can find detailed information about the technical words in the text. ➢ Make research about automotive movement control systems

Suspension System

Car bodies must be suspended on same type of spring devices to isolate them, as much as possible, from the irregularities of the road. The body and frame unit must be rigid and strong to provide secure anchorage for the suspension system, and also to provide positive alignment and the securing of all parts.

Some cars use separate frames, while others use the integral frame and body type of construction. Where the separate frame is used, it is constructed of steel channels and cold riveted together. It has various cross members to provide mounting and bracing points.

There are four types of springs used to suspend the car: leaf spring, coil spring, torsion bar and air spring. Modern practice uses individual wheel suspension on the front of the car. This is accomplished by mounting the wheel assembly on the ends of pivoting control arms. Any of the four springs can be used in this system. Common practice is still utilizing the solid rear axle housing with coil, leaf or air springs. Various combinations of control arms are used, depending on the type of drive. The individually suspended swing type rear axle is finding increased application, especially among foreign imported cars.

Breaker System

Liquids, under confinement, can be used to transmit motion and to increase or decrease pressure. Air is compressible. Liquids are not Pascal's law states, “When pressure is exerted on a confined liquid, it is transmitted undiminished." The brake system can be divided into two principal parts, hydraulic system and wheel brake assemblies. When the brake pedal is depressed, the master cylinder piston compresses brake fluid in the master cylinder. This causes fluid to move in the brake lines. This fluid movement will expand the wheel cylinders, causing them to apply the brake shoes to the brake drums. Both movement and pressure are used in the hydraulic system. Cars now employ double-piston or dual master cylinders. This provides a separate braking force for front and back wheels. Brake lines are made of double thickness, plated steel. No other material is satisfactory. Flexible hoses are used in both the front and in the rear.

CHECKLIST

If you have behaviors listed below, evaluate yourself putting (X) in “Yes” box for your earned skills within the scope of this activity otherwise put (X) in “No” box.

Evaluation Criteria	Yes	No
1. Have you ever had the knowledge of the technical English with brake systems of the car?		
2. Have you ever had the knowledge of the technical English with steering systems of the car?		
3. Have you ever had the knowledge of the technical English with the front layout angles of the car?		
4. Have you ever had the knowledge of the technical English with the suspension systems of the car?		
5. Did you make research on the subject?		

EVALUATION

Please review your"No" answers in the form at the end of evaluation. If you do not find yourself enough, repeat the learning activity. If you give all your answers "Yes" to all questions, pass to the "Measuring and Evaluation".

MEASURING AND EVALUATION

Read the sentences and answer the questions. Then, compare your answers with the answer key at the end of the module.

1. Which one is not a component of the brake system?
- **A)** Brake drum
- **B)** Brake disc
- **C)** Gearbox
- **D)** Combination valve

2. Which one is a type of brake system?
- **A)** Hydraulic type
- **B)** Air-Hydraulic type
- **C)** Air type
- **D)** All

3. Which one is used to reduce the effort needed to steer cars?
- **A)** Manual steering
- **B)** Parallelogram steering
- **C)** Power steering
- **D)** None

4. Which one is used to direct the car?
- **A)** Power transfer system
- **B)** Brake system
- **C)** Steering system
- **D)** Suspension system

5. Which one is the angle between the strut offset from the vertical, towards to back or front of the car?
- **A)** Camber
- **B)** Caster
- **C)** Toe-out
- **D)** None

6. Which one is used as suspension system on the cars?
- **A)** Independent front suspension
- **B)** Double A-arm suspension
- **C)** Mac Pherson strut suspension
- **D)** All

EVALUATION

Please compare the answers with the answer key. If you have wrong answers, you need to review the Learning Activity. If you give right answers to all questions, pass to the next learning activity

LEARNING ACTIVITY-4

AIM

You will use the technical English about automotive electric electronic systems.

SEARCH

- Research the basic definitions and terms with the relevant automotive electric electronic systems using automotive services in your surroundings and at your school workshops and what happening with the equivalents of technical English. Bring into a report the results of making research. Make a presentation to your teacher and your friends in your classroom.

4. AUTOMOTIVE ELECTRIC ELECTRONIC SYSTEMS

4.1. The Principles of the Electric

Electrical current is a flow of electrons, and the more electrons in motion, the stronger the current is.

The greater the concentration of electrons in a battery or generator terminal, the higher pressure between the electrons. The greater this pressure, the greater the flow of electrons.

There are three fundamental characteristics of an electrical circuit:

- Volts = Electrical Pressure
- Amps = The rate of current flow
- Ohms =Electrical Resistance

The flow of electrons through a conductor is called current and is measured in electrons per second or Amperes. The flow of current measured in amperes can be compared to the flow of water in a pipe measured in liter per second.

Voltage is the energy that moves the current (like the pressure that moves the water). Voltage is measured in volts. Voltage is described as the difference in potential charges between the positive and the negative terminals of a battery or alternator. Without voltage no current will flow.

Resistance describes the opposition to current flow. The unit of measurement is the Ohm (ω) which is defined as the resistance that will allow one ampere to flow when the potential is one volt.

There is a mathematical relationship between voltage, current and resistance (Ohm's law). The current flow in a circuit varies directly with the voltage and inversely with the resistance. In others words the pressure of 1Volt applied to 1 Ohm resistance will cause 1 Amp of current to flow. If voltage increases current will increase, if resistance increases current will decrease. If any two of the three terms (volt, amp and ohm) are known the missing one can be found.

$$Volts = Ampers \times \mathrm{Re}\,sis\,\mathrm{tan}\,ce$$

$$Amps = \frac{Volts}{\mathrm{Re}\,sis\,\mathrm{tan}\,ce}$$

$$Ohms = \frac{Volts}{Amps}$$

4.2. Electrical Circuits

The term circuit means a cycle, an unbroken path beginning at a point and returning to the same point.

Basic requirements for an electrical circuit include:

- A voltage source (battery or alternator).
- Connecting wires (conductors).
- An electrical load (lamps, rotor, resisters etc.).

In order for a circuit to be complete there cannot be a break of circuit flow. If there is any sort of break, the circuit becomes an open circuit and will not function.

There are three types of circuits:

- Series is one in which there is only one path for the current to flow.
- Parallel is one which has more than one path in which the current can flow. In such a circuit the current divides to pass through of the devices forming the circuit.
- Series/parallel is a combination of series and parallel circuits. Same devices in the circuit are connected in series while others are in parallel. This is very common in automotive applications.

4.3. Electrical Work and Power

The electrical unit for measuring work is known as Joule (1 Joule=1 Ampere flowing for 1 second under the pressure of 1 Volt). This is the result of the product of a force and the distance through which it acts in overcoming resistance. Power is the rate of doing work.

$$Power = \frac{Work}{Time}$$

$$Watts = \frac{Joules}{Seconds} = Volts \times Ampers$$

4.4. Basic Elements of Electricity

Electricity is the flow of tiny subatomic particles, called electrons, from one place to another. Electrons contain a negative charge; they are attracted to particles of opposite (positive) charge and repulsed by particles with the same charge. It is this force that causes electrons to flow, thereby producing electrical power.

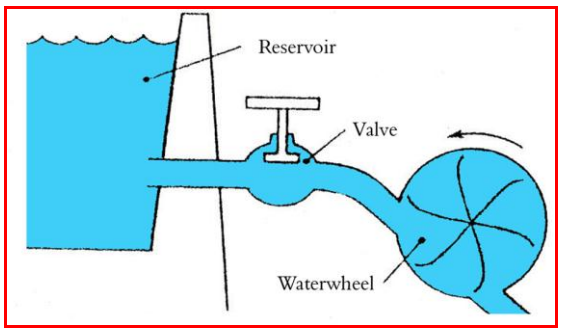

Figure 4.1: Create electric energy

The flow of electricity in a wire can be likened to the flow of water through a pipe. An example is water draining a reservoir to run a waterwheel. The reservoir is like a battery, the valve is like a switch, and the pipes are like wires. The wheel is like an electrical load, which can be a light bulb, an electric motor, an ignition system, or the like. A diagram of three basic electrical components is shown below. The diagram describes a circuit. The circuit includes a return wire from the load to the battery. All electrical circuits form closed loops; without a return, current could not flow.

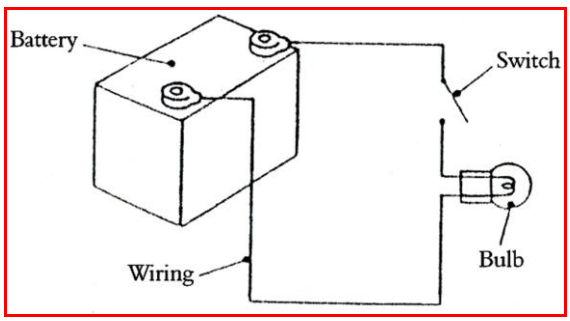

Figure 4.2 Components of basic electrical circuit

The metal body and engine of a car are used as the return wire for all the electrical circuits. This is called grounding, and it reduces the actual amount of wire needed by half.

In a waterwheel system it is sometimes desirable to know the pressure of the water when it emerges from the pipe and how much water is flowing out. The same kind of information is often helpful when discussing electrical circuits.

Pressure in a reservoir system can be estimated simply by knowing how high the water is above the waterwheel. The amount of pressure in an electrical circuit, however, is not so easily seen. It is called voltage, and an instrument called a voltmeter is needed to measure it. The unit of measurement is a volt.

Likewise, the now of water can be seen, but a flow of electrons is invisible. In a circuit, electron flow is called a current. It is measured in amperes with an ammeter. The size of the load in electrical circuits can be measured, too. Load size is cal1ed resistance; it is measured in ohms with an ohmmeter.

These three quantities are connected arithmetically by Ohm's Law:

$$Current = \frac{Voltage}{\mathrm{Re}\,sis\,\mathrm{tan}\,ce}$$

If two of the three quantities are known, the third can be calculated.

For example, if the bulb in the circuit shown above has a resistance of 6 ohms and it is connected to a 12-volt battery, the current flowing through it will be 12 divided by 6, or 2 amperes.

The power consumed by a motor or a light is calculated in watts: wattage is current time voltage. A 15-ampere head-light operating at 12 volts consumes 180 watts of electrical power.

Coupled to the electric force that sends electron running through wires is a magnetic force that always exerts itself at right angles to the direction of the electron current. In most circuits this force is chaotic and negligible. However, if the electrons are made to flow many times in a spiral-as through many turns of wire wrapped around an iron bar-the forces are lined up and create a magnet:

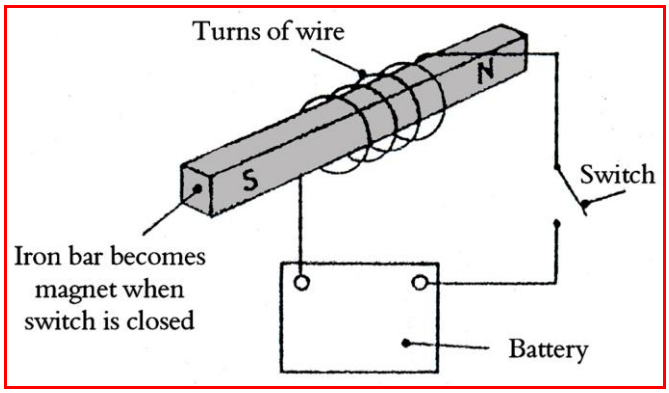

Figure 4.3: Create a magnet

Magnets exert mechanical pull. When oriented in a ring, as in an electric motor, they can be used to pull the motor's shaft continuously around. This is basically the way all electric motors work. It is also the principle behind the operation of solenoid switches; the magnetic pull from a coil of wire can move a rod that will close a door lock or engage the starter motor. When the principle operates in reverse, mechanical motion is converted into electricity, as in a car's alternator.

Because of the way alternators are built, they produce current that changes direction frequently; this is called alternating current (AC). A diode is used to convert this to one-way current, called direct current (DC). Diodes act like one-way valves in water pipes: they al1ow the current to flow in one direction but block flow in the other direction.

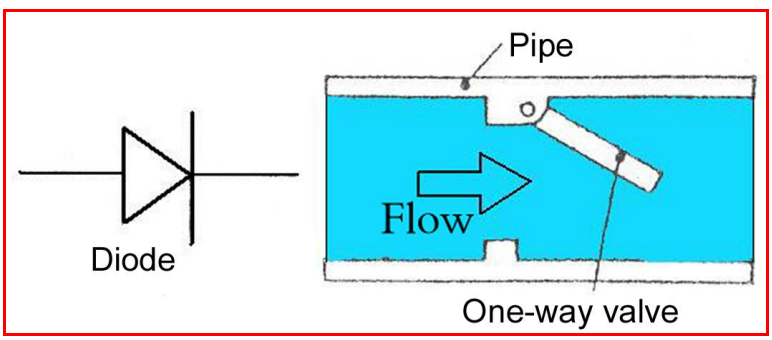

Figure 4.4: Function of diode

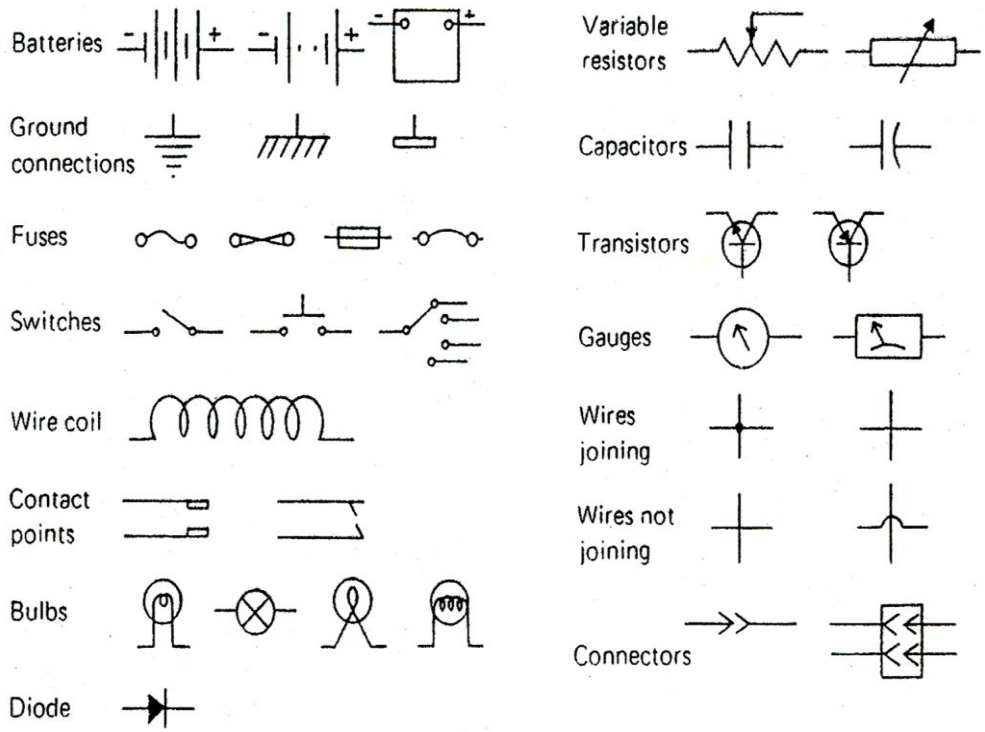

Figure 4.5: Electrical symbols

Many of which are standard throughout the automotive industry are used in diagrams of car wiring to indicate electrical components and wire connections.

4.5. The Battery

The battery supplies electricity to the ignition system, starter motor, lights, and a car's other electrical equipment.

The battery is made up of a number of cells, each with just over 2 volts, whose terminals are linked by metal bars. Modern car batteries have six cells, giving a total output of 12 volts.

Each cell consists of two sets of plates, or electrodes, in a solution of water and solution acid (called the electrolyte). One set of plates is made of lead peroxide; the other, of porous lead.

When a cell is functioning, the acid reacts with the plates, converting chemical energy into electrical energy. A positive charge is built up on the lead peroxide electrode and a negative charge on the lead electrode.

Electric current, measured in amperes, flows from one terminal of the battery, through the car's electrical system, to the opposite battery terminal, and then through the electrolyte.

As the chemical reaction goes on, lead sulfate forms on the surface of both electrodes, and the sulfuric acid gradually turns to water. When the surfaces of both plates have become fully coated by lead sulfate, the battery is discharged. Recharging the battery with an electric current restores the electrodes to their original condition and regenerates the sulfuric acid.

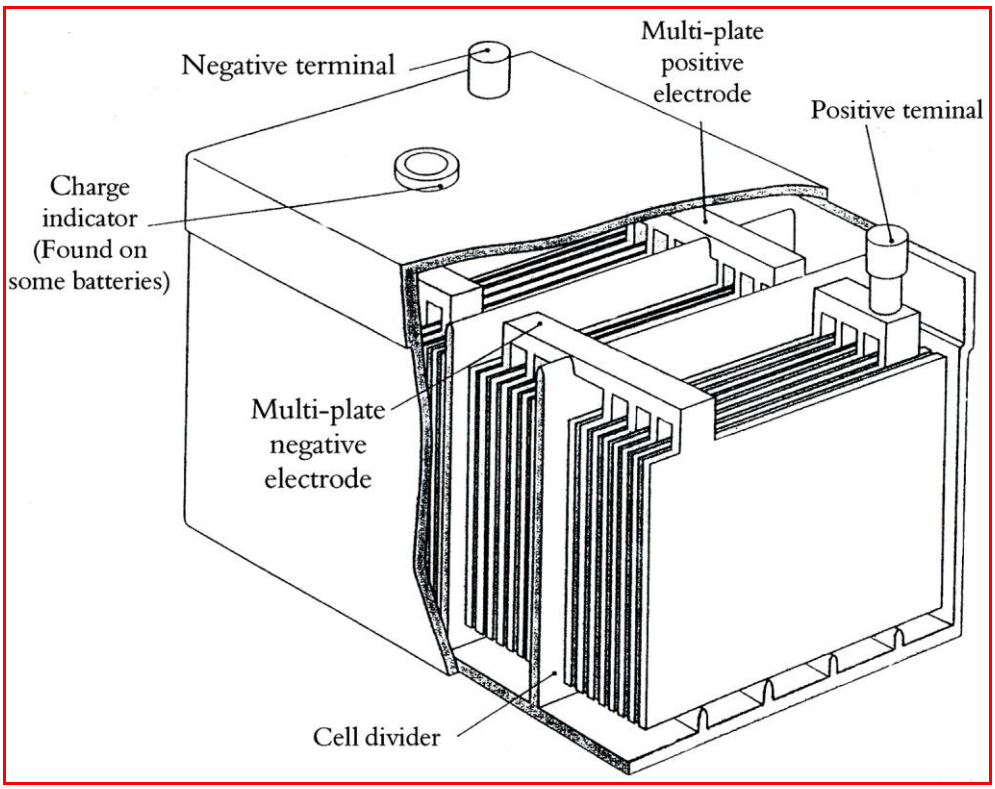

Figure 4.6: Structure of battery

A battery eventually goes dead and cannot be recharged for a number of reasons: The plates may become so encrusted with sulfate that a charge cannot get through to them. The plates may disintegrate. Or current leakage between cell plates can cause a short circuit.

Battery capacity is measured in several ways. The most useful is the zero cold test which tells how many amperes a battery can deliver at 0°F over a period of 30 seconds before any cell falls below 1.2 volts. A large engine may need a 400-ampere battery to adequately start it; a small engine, only a 250-ampere battery. Another rating is reserve capacity-the number of minutes that a battery can run a car if the alternator is not working.

The heaviest demand made on a battery occurs when the car is being started. During the short period that the starter is turning the engine over, it may be drawing as much as 400 amperes from the battery. (Headlights, in comparison, draw about 15 amperes, and taillights

only 1.5 amperes). Because of this high current drain, the starter should never be operated for more than 30 seconds at a time; it should then be allowed to rest for a minute, to reduce the change of draining the battery completely.

Once the engine is running, the alternator generates enough current to recharge the battery and keep it charged.

Electrical energy can be stored as well as produced by two metal plates immersed in a chemical solution (Figure 4.7-A). The larger the surface area of the plates, the more energy can be stored. Large surface areas are achieved by using a stack of plates connected alternately (Figure 4.7-B). Non conducting porous plate separators prevent short circuits. Each stack of plates forms a cell with a voltage of slightly more than 2 volts. Cell voltage remains the same no matter how large the cell is made. To achieve higher voltages, cells must be connected in series; for example, six cells will produce 12 volts.

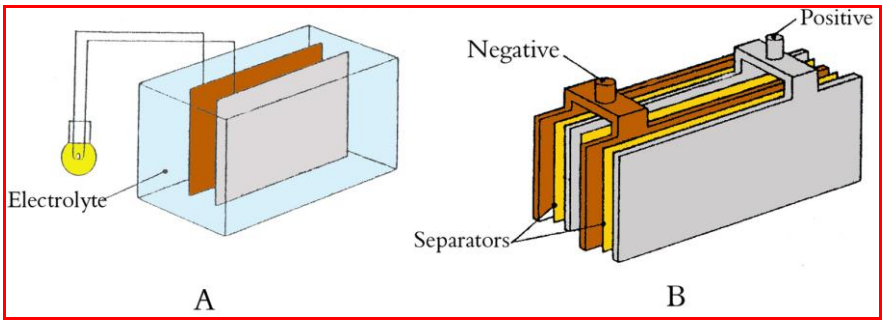

Figure 4.7: Create electric energy into battery

Built-in indicator shows state of charge and level of battery fluid. When battery is more than 65 percent charged, ball floats to tip of plastic rod and is visible in round window as a green dot (Figure 4.8-A). When battery needs recharging, ball sinks and dot disappears. If window remains dark (Figure 4.8-B), fluid level still covers plastic rod. When level drops window becomes clear (Figure 4.9-C), indicating that water must be added or battery discarded.

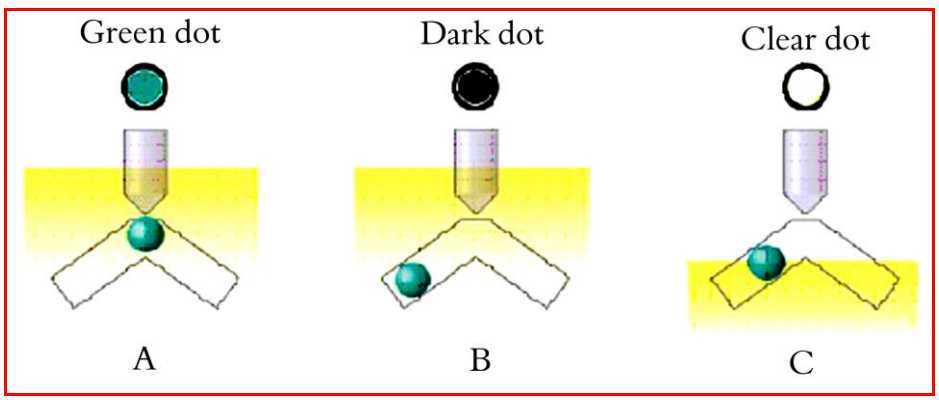

Figure 4.8: Bolt-in indicator of battery

4.6. The Starter

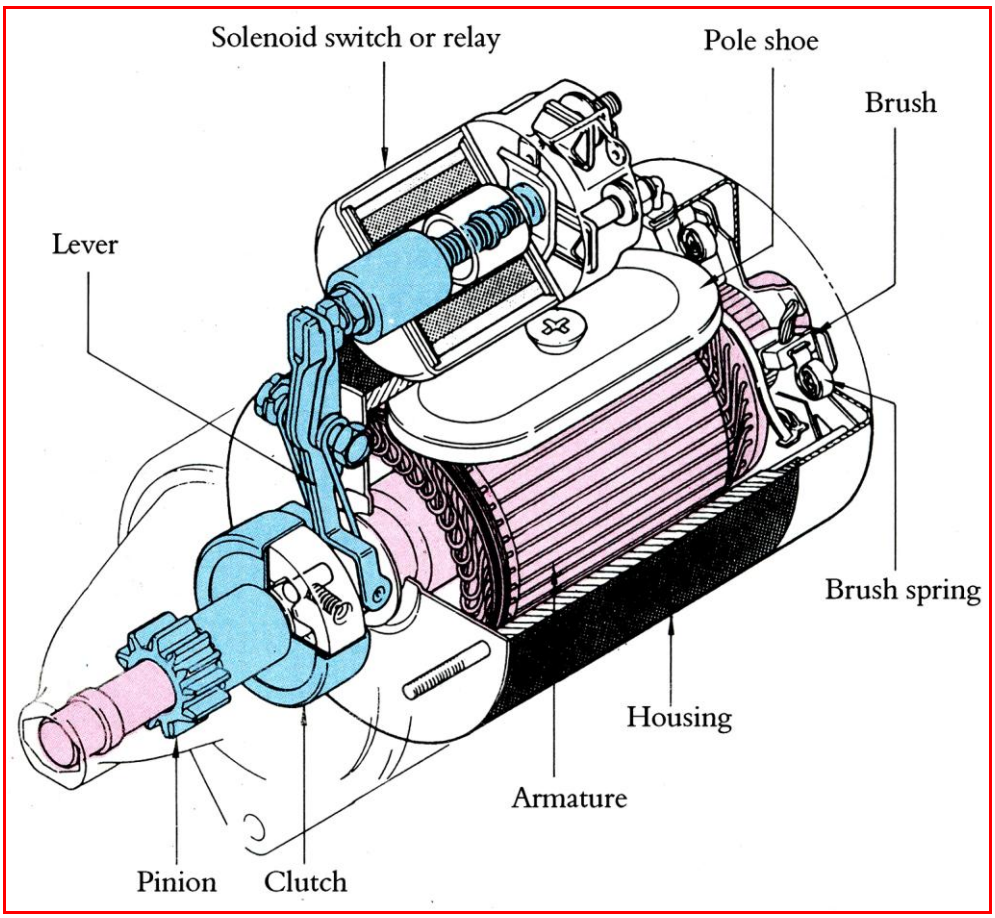

Figure 4.9: Structure of starter

The starter is a conventional electric motor designed to turn the engine unit fires. Most car engines have to be rotated at 50 to 150 rpm before they will start. This requires considerable electric power, particularly in winter, when the engine is cold and the oil is thick.

To manage this high current, a switch called a solenoid is frequently used to turn on the starter. The solenoid and/or starter may be triggered by a relay.

The starter turns the engine's crank-shaft through a pair of gears. One, the pinion, is mounted on the starter shaft. It engages with the other, the flywheel, which rotates the crankshaft. The gear ratio between pinion and flywheel is generally about 10:1 that is, the torque of the starter is multiplied 10 times.

When the engine fires the starter pinion must disengage from the flywheel. Otherwise, the engine will run the starter motor at a high speed and damage it.

The starter works in the same way as any electric motor-it depends on the force that magnets exert on each other. The south pole of a magnet is attracted to the northern pole of another, and vice versa. Inside, a starter is a set of fixed electro-magnets called the field magnets, or field windings. Between them is the armature-another set of electromagnets that change polarity as they turn, becoming south whenever north on a field magnet is approached, and vice versa.

The change of polarity is achieved by a rotating commutator that makes contact with a pair of carbon brushes.

Some starters differ from the General Motors unit shown here. Chrysler starters have an extra set of gears between the starter shaft and the pinion to further multiply torque. On Ford starters, the lever that engages the pinion gear is moved by a pole inside the starter rather than by a solenoid switch. The pole is activated whenever current flows through the starter motor coils.

4.6.1. The Relay

To start the engine, the driver turns the starter switch, which closes a relay on some cars, allowing current to flow to the starter. A relay is, in effect, a switch, turned on by a switch, a complication made necessary because of the high current the starter must handle. Inside the solenoid switch, a small current flow through the electromagnet, which then pulls a contact plate against two heavy-duty, high-current terminals, allowing current to flow.

4.6.2. How the Solenoid Switch Engages the Starter

When a solenoid switch is closed, it simultaneously actuates a lever that pushes the starter pinion into engagement with the engine flywheel. The starter then cranks the engine until it fires and runs of its own accord. As the engine picks up speed, it is prevented from turning the starter shaft any faster by a one-way overrun clutch, thus protecting the starter from damage. When the driver releases the starter switch, the pinion disengages.

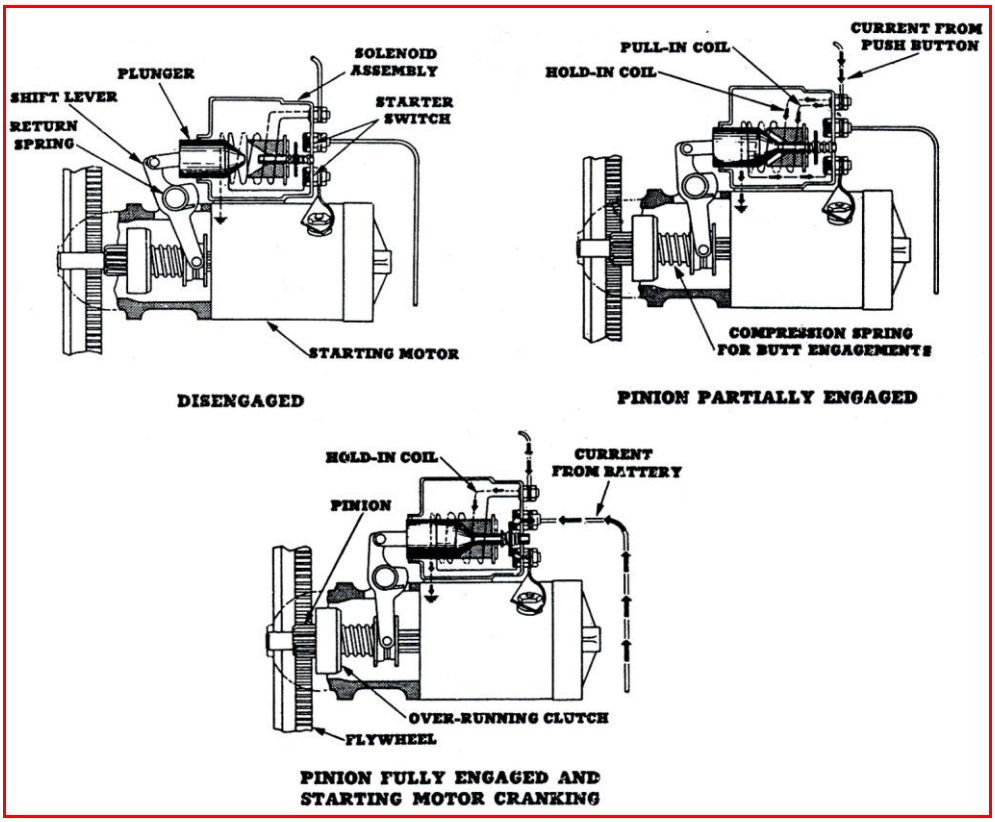

Figure 4.10: Electric solenoid operation

4.7. The Alternator

Without a generator, the electrical demands of a modern car would soon drain a fully charged battery. The generator is mounted at the front of the engine and is connected to the engine crankshaft by the fan belt. Electricity is generated when the engine turns the fan belt.

Car generators used to be the type that produced direct current (DC); now only AC generators-called alternators-are used. Alternators generate alternating current (AC), which must be converted to DC. But alternators are lighter and more reliable than the older DC generators.

An alternator can produce more current than a DC generator of the same size. This gives it an advantage in heavy traffic and permits the use of extra electrical accessories.

The amount of current generated depends on how fast a generator turns; the alternator can be geared to run at relatively higher speeds because its interior parts are lighter than those inside a DC generator. As a result, alternators generate some electricity even when the car engine is idling. DC generators could not be adjusted to do this without gearing them to

run too fast at highway speeds or setting the idle speed of the engine at an unusually high and wasteful level.

As in a generator, current is produced in an alternator when a wire crosses a magnetic field. In an alternator, however, the wire, in coiled form, is held stationary and the magnetic field is turned.

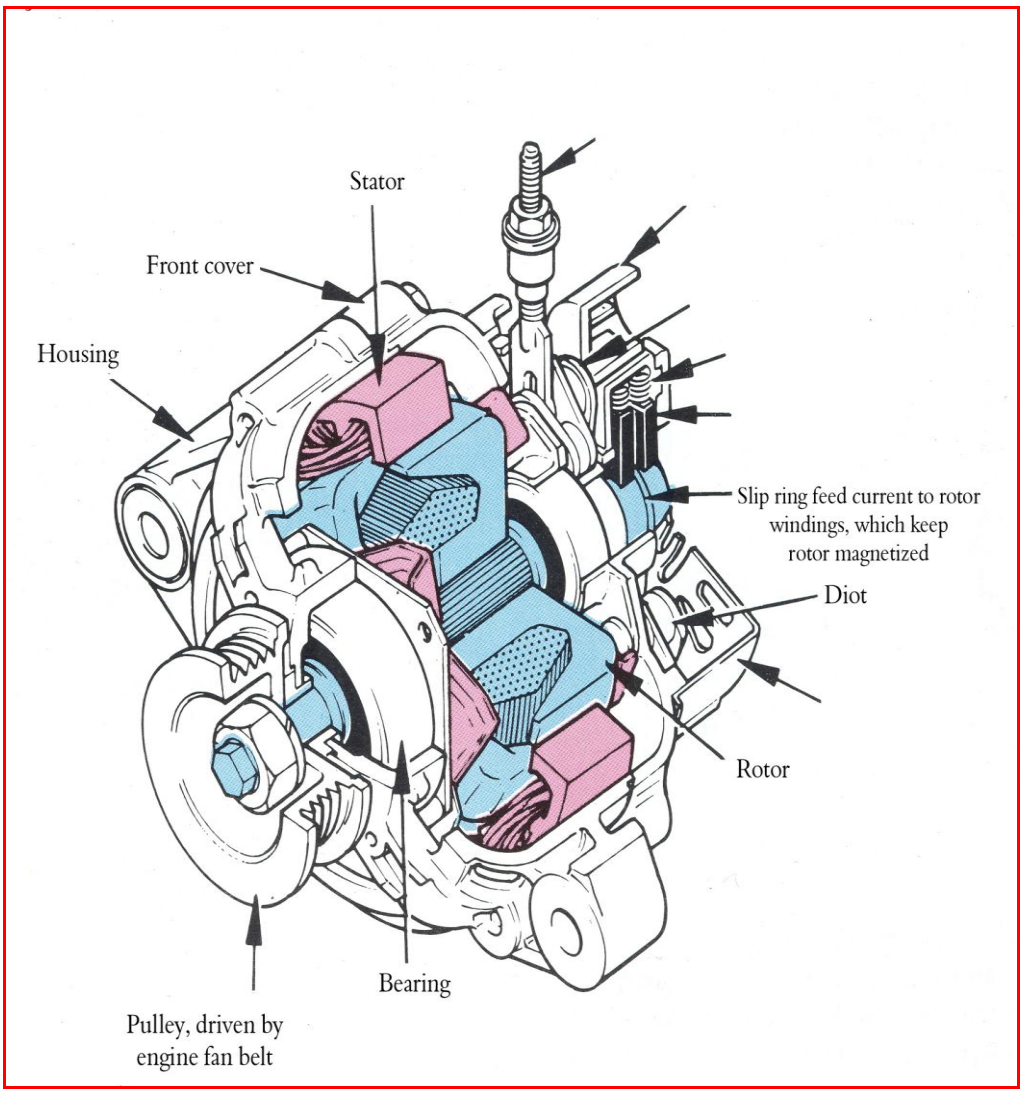

Figure 4.11: Structure alternator

Because the battery and everything else electrical in the car works on DC, the AC output of the alternator must be converted to DC. This is done with semiconductor rectifiers made from silicon. Rectifiers pass current in one direction only. The silicon rectifiers are mounted inside the alternator housing. Before the advent of silicon semiconductors, rectifiers

were very large and troublesome to cool, and alternators were used only on large commercial vehicles.

4.7.1. Rotor

Rotating part of alternator (rotor) includes an electromagnet that is magnetized by current from the battery. Current flows into rotor windings via slip rings. North and south poles are shaped like interlocking fingers to create an alternating field as the rotor turns.

4.7.2. Stator

Stationary coils in an alternator (called the stator) intercept the rotating magnetic field produced by the rotor. Interception of the field is enhanced by a cylindrical core made of laminated soft iron.

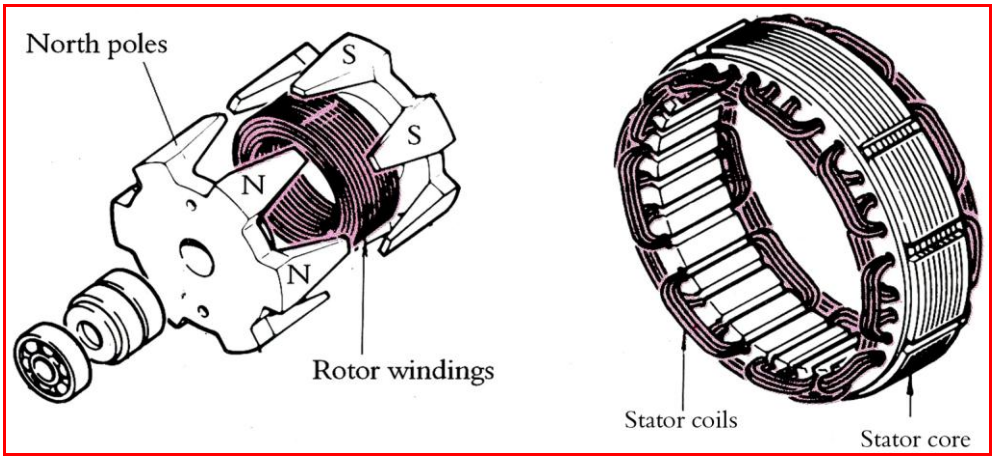

Figure 4.12: Rotor and stator

4.7.3. Generating Alternating Current

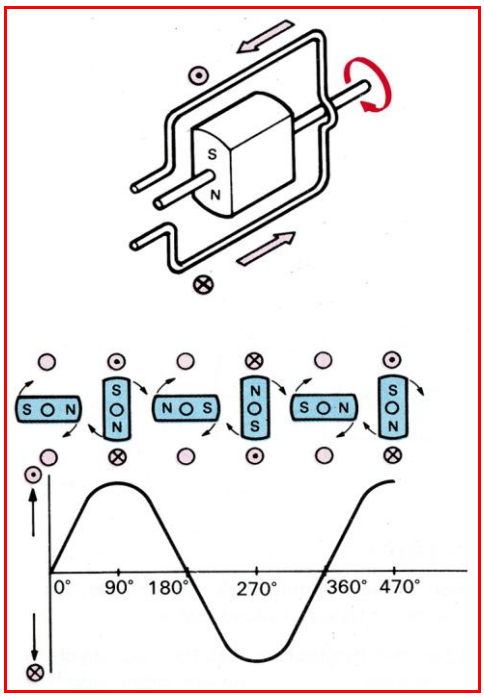

Figure 4.13: Generating alternating current

Alternator works on the principle that an electric current is generated in a wire whenever the wire passes through a magnetic field. For the field, the alternator has an electromagnet operated by a small amount of current from the battery; the current reaches the electromagnet coils via slip rings on the alternator shaft. As the electromagnet is turned by the car engine, the field is intercepted by the outer loop of wire, and current flows through the wire first in one direction, then in the other, resulting in alternating current.

4.7.4. Voltage Regulators

Voltage regulator prevents overcharging of the bat1ery by reducing current to the rotating electromagnet as the engine speeds up. This limits the alternator's voltage output. Older type of regulator was an electromechanical vibrator; these have mostly been replaced by circuits using semiconductor diodes in a sealed unit mounted inside alternator or sometimes outside it. Cars with electromechanical regulators have a field relay in the regulator unit to keep the battery from discharging through the alternator when the engine is off.

4.7.5. Testing and Replacing Alternators and Voltage Regulator

Alternators are part of a car's charging system, which also includes a voltage regulator, the battery, and a dashboard warning light or gauge.

A defect in the charging system will ultimately produce a dead battery, and the car will not start. However, a number of conditions will appear in advance to warn that trouble is brewing.

If a dashboard warning light turns on, it is easily seen. If the car has any meters, they also can signal an abnormality, although you will have to make it a habit to check them periodically. An interpretation of these dashboard warnings is given in the chart on the facing page. Another warning may come from the headlights if they gradually dim during night driving.

The cause of these warnings may be nothing more than an overload on the system, which can occur when such add-on accessories as high-powered audio equipment and high-intensity driving lights are all turned on at once. If so, you must turn off some of the accessories or inst3.11 a heftier alternator.

At any hint of a problem in the charging system, first look at the fan belt. Turn on all lights and accessories, and have a helper rev up the engine. A loose fan belt will either whines, squeal, or slip; a glazed belt will slip.

A belt can also be too tight. Set the tip of a screwdriver against the alternator (if you can reach it) and place your ear against the screwdriver handle. If you hear a rough or grinding noise from the alternator, it means that the bearings are worn, probably by a tight fan belt. Loosening the belt may restore the alternator to service; otherwise, the alternator must be replaced.

A less obvious problem is battery overcharging by a defective voltage regulator. This will cause the battery to need frequent refills or replacements. The on-car tests, opposite, will isolate a faulty regulator.

If you lack the equipment or time for tests, remove the alternator from the car and take it to an auto parts supplier who can test it.

When replacing an alternator, take off the fan and keep it if the replacement alternator does not come with a fan.

Caution: Except for tests during which the engine must be running, disconnect the ground cable from the battery before beginning work on electrical parts. Failure to do so may result in sparks that can damage equipment and burn hands.

4.8. Car Wiring

About 200 feet of wire link the electrical components in a modem car. All the wiring-with the exception of grounding straps, battery leads, and high-voltage ignition wires-is wrapped with insulation of various colors to permit quick recognition when repairs are necessary.

Manufacturer's repair manuals usually include a complete diagram of the car circuits. These diagrams are intended to help you identify the wires by their colors but bear little or no relationship to the actual positions of the wires and components in the car. The diagrams use symbols like those on the facing page to represent components.

They are located inside a car. The entire system is divided into an ignition circuit, a starter circuit, a charging circuit, lighting circuits, and accessory circuits.

Colors are used in the illustration to distinguish the various circuits; the colors are not meant to represent the color-coding system of a particular car. A few electrical accessories have been omitted below for the sake of clarity.

The battery supports the electrical system by supplying current to the lights and accessories when the engine is not running and by supplying the power that starts the engine. After the engine is running, the alternator takes over, recharging the battery and meeting all the other electrical requirements of the car.

APPLICATION ACTIVITY

Use technical English about the automotive electric electronic systems.

Steps of process	Suggestions
➢ Find a text about this process and translate. ➢ Translate the text given below	➢ Please read all of the text. ➢ If you do not know words in text, research the meaning during translation ➢ Use English dictionary for the meaning of words from English to Turkish ➢ You can find detailed information about the technical words in the text. ➢ Make research about automotive electric electronic systems

The electron theory states that electricity is caused by a flow of electrons through a conductor. There is a shortage of electrons at one end of the conductor and a surplus at the other. Whenever this condition is present, current will flow.

An atom is made of neutrons, proton s and electrons. The electron is a negative charge of electricity, while the proton is positively charged. The neutron is neutral, electrically.

The free electrons in an atom are those that are relatively easy to "shake" out of orbit. The free electrons are those that cause the current flow. The pressure that causes current to flow is VOL TAGE. The amount of current flowing is measured in AMPERES. Every conductor will have some RESISTANCE to the movement of electrons.

BATTERY

A battery is an electrochemical device. It contains positive and negative plates that are connected in such a way as to produce three or six groups or cells. The plates are covered with electrolyte. A charged battery will amass (gather a great quantity) a surplus of electrons at the negative post. When the battery is placed in a completed circuit, the electrons will flow from the negative post, through the circuit, and on to the positive post.

The battery must be kept charged by passing electricity through it in a reverse direction to that of battery current flow.

STARTER

The starter is used to crank the engine for starting purposes.

The starter motor utilizes a current carrying series of armature loops placed in a strong magnetic field produced by field coils. As the armature loops are repelled by the magnetic field, the armature is forced to spin. By arranging a sufficient number of loops and connecting them to commutator bars or segments, current in the loops keeps reversing so the repelling force will remain constant. This allows the armature to continue spinning.

CHECKLIST

If you have behaviors listed below, evaluate yourself putting (X) in “Yes” box for your earned skills within the scope of this activity otherwise put (X) in “No” box.

Evaluation Criteria	Yes	No
1. Have you ever had the knowledge of technical English about the principles of the electric?		
2. Have you ever had the knowledge of technical English about basic elements of electricity in the car?		
3. Have you ever had the knowledge of technical English about the car batteries?		
4. Have you ever had the knowledge of technical English about the car starters?		
5. Have you ever had the knowledge of technical English about the car alternators?		
6. Did you make research on the subject?		

EVALUATION

Please review your "No" answers in the form at the end of the evaluation. If you do not find yourself enough, repeat learning activity. If you give all your answers "Yes" to all questions, pass to the "Measuring and Evaluation".

MEASURING AND EVALUATION

Read the sentences and answer the questions. Then, compare your answers with the answer key at the end of the module.

1. Which one is energy (Electrical Pressure) that moves the current?
- **A)** Voltage
- **B)** Resistance
- **C)** Amperes
- **D)** None

2. Which on describes the opposition to current flow?
- **A)** Voltage
- **B)** Resistance
- **C)** Amperes
- **D)** None

3. Which one is a type of circuit?
- **A)** Seri circuit
- **B)** Parallel circuit
- **C)** Combination (Seri/Parallel) circuit
- **D)** All

4. Which one supplies electricity to the ignition system, starter motor, lights and car's the electrical equipment?
- **A)** Alternator
- **B)** Battery
- **C)** Wiring
- **D)** All

5. Which one is a conventional electric motor designed to turn the engine?
- **A)** Alternator
- **B)** Battery
- **C)** Starter
- **D)** Wiring

6. Which one wires link the electrical components in a modern car?
- **A)** Car wiring
- **B)** Electrical system
- **C)** Battery
- **D)** None

EVALUATION

Please compare the answers with the answer key. If you have wrong answers, you need to review the Learning Activity. If you give right answers to all questions, pass to the module evaluation.

MODULE EVALUATION

Read the sentences and answer the questions. Then, compare your answers with the answer key at the end of the module.

1. Which one is the position that two valves are opened and that the piston is at T.D.C. during the end of the intake stroke and start of exhaust stroke?

A) Overlap of the valves
B) The end of the compression stroke
C) Power stroke
D) Compression stroke

2. Which one is attached to the piston and the small end of the connecting rod?

A) Locking bolt
B) Nut
C) Piston pim
D) Rod cab

3. Which one is product cylinder volume and cylinder numbers of an engine?

A) Total volume
B) Stroke volume
C) Total cylinder volume
D) Compression ration

4. Which one is used to scrape the surplus of oil from the cylinder walls?

A) Compression ring
B) Oil control ring
C) Oil pump
D) Piston

5. Which one is method of connecting piston and connecting rod?

A) Locked type
B) Semi-floating type
C) Full-floating type
D) All

6. Which is the engine that has two banks of cylinders mounted directly opposite each other on the crankcase?

A) In-line engine
B) L type engine
C) V-Formation engine
D) Horizontally opposed engine

7. Which requirement must pistons have?
- **A)** Strong enough to withstand high temperatures
- **B)** It must be able to keep the cylinder wall lubricated
- **C)** Small amount of frictional resistance
- **D)** All

8. Which one is the volume which is between top dead center and bottom dead center?
- **A)** Total volume
- **B)** Cylinder volume
- **C)** Combustion chamber volume
- **D)** Stroke volume

9. Which one is not the classification of the engine according to cylinder design?
- **A)** In-line engine
- **B)** The cooling system with air engine
- **C)** V-Formation engine
- **D)** Horizontally opposed engine

10. Which one is not the classification of the engine according to the valve system of engine?
- **A)** L type
- **B)** H type
- **C)** I type
- **D)** F type

11. Which one is used for distributing the air-fuel mixture?
- **A)** Intake manifold
- **B)** Valve
- **C)** Exhaust manifold
- **D)** Spark plug

12. Which one acts as a reservoir for oil and at the same time serves as a collector dust at the bottom of the engine?
- **A)** Cylinder head
- **B)** Oil pan
- **C)** Manifolds
- **D)** Oil pump

13. Which one is designed to prevent leakage between the piston and the cylinder?
- **A)** Compression ring
- **B)** Oil control ring
- **C)** Piston
- **D)** Valve

14. Which one is the function of the lubricating oil?

- **A)** Wearing resistance
- **B)** Cooling
- **C)** Clearing
- **D)** All

15. Which one connects the engine to gear box (transmission)?

- **A)** Clutch
- **B)** Differential
- **C)** U-joint
- **D)** None

16. Which one reduces the speed of the engine to increase tork according to road conditions?

- **A)** Transmission
- **B)** Clutch
- **C)** Differential
- **D)** None

17. Which one is the function of the differential?

- **A)** Turning the flow of power 90 degree
- **B)** Stepping down engine revolutions a final time
- **C)** Diving power flow between the rear wheels
- **D)** All

18. Which one is used to stop the car?

- **A)** The power transfer system
- **B)** Brake system
- **C)** Steering system
- **D)** Suspension system

19. Which one is used gearbox in the steering system?

- **A)** Rock and pinion gearbox
- **B)** Worm and roller gearbox
- **C)** Recirculating-ball gearbox
- **D)** All

20. Which one is the inward or outward tilt of the wheel?

- **A)** Camber
- **B)** Caster
- **C)** Toe-in
- **D)** Toe-out

21. Which one transfers some of the braking forces from the wheel to the frame and also resists body roll in turns?

A) Suspension system
B) Stabilizer bar
C) A-arm
D) Coil spring

22. Which one requires an electrical circuit?

A) A voltage source
B) Connecting wires
C) An electrical load
D) All

23. Which one is used measuring unit as work for electrical equipments?

A) Pascal
B) Volt
C) Joule
D) None

24. Which one produces electricity in a modern car?

A) Alternator
B) Battery
C) Starter
D) None

25. Which one prevents overcharging of the battery?

A) Alternator
B) Voltage regulator
C) Starter
D) All

EVALUATION

Please compare the answers with the answer key. If you have wrong answers, you need to review the Learning Activity. If you give right answers to all questions, please contact your teacher and pass to the next module.

ANSWER KEYS

LEARNING ACTIVITY 1 ANSWER KEY

1	A
2	D
3	D
4	C
5	C
6	D
7	D
8	B
9	A
10	B
11	C
12	B
13	C
14	B
15	A
16	B
17	C
18	D
19	C
20	D

LEARNING ACTIVITY 2 ANSWER KEY

1	D
2	D
3	D
4	C
5	C
6	C

LEARNING ACTIVITY 3 ANSWER KEY

1	C
2	D
3	C
4	C
5	D
6	B

LEARNING ACTIVITY 4 ANSWER KEY

1	**A**
2	**B**
3	**D**
4	**B**
5	**C**
6	**A**

MODULE EVALUATION ANSWER KEY

1	**A**
2	**C**
3	**C**
4	**B**
5	**D**
6	**D**
7	**D**
8	**D**
9	**B**
10	**B**
11	**A**
12	**B**
13	**A**
14	**D**
15	**A**
16	**A**
17	**D**
18	**B**
19	**D**
20	**A**
21	**B**
22	**D**
23	**D**
24	**A**
25	**B**

SOURCES

- STOCKEL Martin W, **Auto Mechanics Fundamentals**, The Goodheart-Willcox Company, South Holland Illinois ,1974.
- Robert Bosch GmbH, **Bosch Automotive Handbook**, Germany, 1996.